Dr Jos. Leidy.

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OF THE

AMERICAN PHILOSOPHICAL SOCIETY.

HELD AT PHILADELPHIA, FOR PROMOTING USEFUL KNOWLEDGE.

VOL. XII. JANUARY TO JULY, 1871.—2 No. 86.

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Vol. XII

JANUARY 1871 TO DECEMBER 1872

PHILADELPHIA:
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1873.

PROCEEDINGS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY

Vol. XII. 1871. No. 86

Stated Meeting, January 6.

Present, seventeen members.

Geo. B. Wood, President, in the Chair.

Mr. Eckley Coxe, lately elected, was presented to the presiding officer and took his seat.

The resignation of Dr. D. F. Condie on account of ill health was received, and accepted.

A photograph of Mr. Thomas Davidson, dated Geological Society, Somerset House, London, Dec. 6, 1870, was received.

Letters of acknowledgment were received from the London Geological Society (Proceedings No. 82); the Smithsonian Institution (83); and the Swiss Society at Berne, dated November, 1869 (Proceedings, vols. X and XI).

Donations for the Library were received from the Moscow N. H. S., Boston Geological Society, Swiss Society, Bavarian Academy, R. Institution of G. B., London Meteorological, Chemical and Geological Societies, Leeds Philosophical Society, R. Dublin Society, Peabody Museum at Boston, Boston N. H. S., Silliman's Journal, American Antiquarian Society, Franklin Institute, College of Physicians, Penn Monthly, U. S. Observatory, the Treasury Bureau, and Editors of Nature.

The decease of Wm. Chauvenet of St. Louis, a member of the Society, at St. Paul, Dec. 13, 1870, was announced by the Secretary.

The decease of Joshua J. Cohen, a member of the Society, at Baltimore, November 4, 1870, aged 70 years, was announced by Prof. Trego.

The decease of Albert Barnes, a member of the Society, at Philadelphia, Dec. 24, 1870, aged 72 years, was announced by Mr. Fraley.

Dr. Geo. B. Wood communicated the results of experiments on the best method of reviving fruit trees.

Prof. Cope communicated the discovery of a new genus of fish from the Green River Country.

Mr. Chase described the methods adopted by the Meteorological Board of the Royal Society, which he had lately visited in London.

The Report of the Judges and Clerks of the annual election was read, by which the following members were declared duly elected to fill the respective offices of the Society for the ensuing year.

President.

George B. Wood.

Vice Presidents.

John C. Cresson, Isaac Lea, Frederick Fraley.

Secretaries.

Charles B. Trego, John L. LeConte,
E. Otis Kendall, J. P. Lesley.

Curators.

Hector Tyndale, Elias Durand, Joseph Carson.

Treasurer.

Charles B. Trego.

Counsellors to serve three years.

Isaac Hays, Henry C. Carey,
Robert E. Rogers, Robert Bridges.

Mr. Lesley was nominated Librarian.

Pending nominations for membership, Nos. 661 to 668 were read.

The Publication Committee reported upon the subject of the publication of Dr. H. C. Wood's Memoir of the Fresh Water Algæ of the United States.

The Report of the Finance Committee, postponed from the last meeting, was read by its Chairman, Mr. Fraley; and the sums recommended by the Committee were, on motion, appropriated for the expenses of the ensuing year. A further recommendation to increase the insurance on the Hall, was on motion adopted; and the meeting was adjourned.

REVIVAL OF FRUIT TREES *prematurely ceasing to bear fruit, or prematurely decaying*, by GEO. B. WOOD, M. D.

(*Communicated to the American Philosophical Society*, January 6, 1871.)

It is well known that most fruit trees, especially the peach and apple trees, in sites where they have been long cultivated, often cease to bear fruit, and even perish, long before their natural period. Thus the peach, which has a normal life of 50 or 60 years, or longer, and grows under favourable circumstances to the size of a considerable tree, generally, in this part of the United States, ceases to bear fruit after two or three years of productiveness, and soon after begins to decay, seldom living beyond 15 or 20 years. The apple tree also, long before it has attained its normal length of life, often ceases to yield fruit, either for a time or permanently, without apparent cause; and trees, planted on the site of an old orchard which has been removed, not unfrequently refuse to bear at all, or at least to a profitable extent.

It is obviously of great importance to discover the cause or causes of such failures, and, if possible, to apply a remedy or preventive. Unless I greatly deceive myself, I have succeeded in showing that the evil generally has its source in a deficiency of the salts of potassa in the soil, and may be corrected by supplying that deficiency.

The alkali potassa, in combination generally with one or another of the vegetable acids, is an essential ingredient in all plants, excepting the sea plants, in which its place is supplied by soda. In living vegetables it is contained dissolved in the juice, and is consequently most abundant in the most succulent parts; and, when the plants are burned, the alkali is left behind in the ashes, of which it constitutes an exceedingly variable proportion, according to the peculiar plant or part of the plant burned. Thus, while the ashes of oak wood contain only about 3 parts in 1000, those of the common poke, the growing wheat stalk, and the potato stems, contain 48 or 50 parts or more. The greater portion by far of the alkali is in the state of carbonate, with a little in the caustic state, and being, in these conditions, very soluble in water, is extracted by lixiviation

with water, and obtained by evaporating the ley. A much smaller portion is in the form of silicate, which is left behind in the ashes after lixiviation, and gives to the soap-boilers' ashes almost all if not quite all their value as a manure. It is, however, only the fresh-burned ashes, not yet submitted to lixiviation, and consequently still containing the potash in its soluble state, that is applicable to the purpose of supplying the alkali to fruit trees in the mode in which I employ it.

When plants are no longer supplied with the requisite amount of potash, they cease to grow, and at length generally perish. In the case of the succulent fruit trees, as the alkali is required in the largest proportion in the fruit, this is the first to suffer; then the leaves gradually fail; and at length the whole tree dies, limb after limb.

How I came to discover this source of premature failure of fruit trees, and to supply the deficiency by means of the soluble potash contained in fresh ashes, I explained, so far as the peach tree is concerned, in a communication made last year to the Society, which was published in the Proceedings.

In that communication I stated that, believing with most others that the peach tree perishes prematurely, in consequence of being attacked near the root by a species of worm, I employed as a remedy against this parasite, after scraping as far as possible the worm out of the root with a knife, fresh ashes in an excavation about the stem of the plant; supposing that, by their caustic power, they might destroy any remains of the insect or its eggs. This method was not original with myself; as I had seen it practiced in my youth very effectually in keeping a peach orchard in bearing for several years.

The peach trees on which I tried the experiment had long ceased to bear fruit, and were in the last stage of decay; in several instances one or more branches being absolutely dead, and the stem being covered with lichens, as is apt to happen with dying trees.

This was done in the Autumn; the earth having been removed around the stem of each tree to the depth of four or five inches, so as to lay bare the upper surface of the main roots, and the excavation filled with fresh ashes. Next Spring a marvellous change was experienced by the trees. They had recovered more than the vigor of their early life, and bore fruit in an abundance which I had rarely, if ever, witnessed.

I could not conceive that such a result should proceed so rapidly, from the destruction of a few worms. Besides, some of the trees had no worms that could be observed; and yet they had been as far gone, and were as much revived as the others.

I was, therefore, driven to the conclusion, that the ashes had not acted by destroying the worm, but by furnishing to the trees a material necessary to their existence, and from the want of which they were perishing. This could only be the soluble potash contained in the ashes, which being dissolved by the rain, was carried in solution along the roots to the minute rootlets where it was needed.

One important inference, which may be here incidentally mentioned, is

that the peach trees were not dying from the worms, but that these attacked them because they were dying from other causes; and it is probably true, as a general rule, that plants in perfect health are in a condition to protect themselves against destructive parasites, probably because the salts of potash in their vessels are repulsive or even destructive to the parasites, which destroy the plant in the absence of this defense. I am not certain even that the curculio may not attack certain fruits, the plum for example, in consequence of deficiency of the alkali in its juice.

At first my experiments were confined to the peach tree; but it may be remembered that I said in my communication to the Society that the principle was applicable as well to other fruit trees, especially the apple, which often refuses to bear, apparently capriciously, but probably from the same deficiency of potash in the soil.

Last year I had the opportunity of testing the correctness of this supposition. I happened to have two apple orchards; one of them old, perhaps 60 years or more, the other comparatively young, having been planted, 15 or 20 years since, upon a piece of ground which had previously been the site of an apple orchard for I presume nearly a century. Both of these orchards might be considered as nearly or quite barren; the old orchard not having borne fruit of any account for 5 or 6 years; and the young one having never borne at all.

In the Autumn of 1869, I tried with these trees the same experiments as in the Autumn before I had tried with the peach trees. The earth was dug from around their stems to the depth of about 5 inches, and the excavation filled, in each case, with about half a bushel of fresh ashes. As regards the old orchard, a part was allowed to remain without treatment, so as to secure the effect of contrast. In the following Spring and Summer (1870), my expectations were fully realized. Early in the season a striking difference was observed between the trees not treated with ashes and those which had been so treated. A dividing line could be observed between the two sections of the orchard; the trees which had been ashed being forward both in leaf and blossom, while the others had made little progress; and the same contrast was presented in the fruit; the trees left to themselves continuing barren, while the ashed trees were loaded with apples. The young orchard, which had never borne fruit of any account, was also made for the first time very productive.

A similar experiment I tried on several fruit trees of different kinds in my garden in town. Though the ashes were applied in Spring instead of of Autumn, the trees in the growing season gave evidence of a similar result. The trees were richly covered with blossoms, which were just becoming exchanged for young fruit, when the famous hail storm which proved so destructive in this city last Summer, put an end to the experiment by stripping the trees of blossom and fruit, and to a great extent even of their leaves.

Among the trees was a very old Newtown pippen tree, probably of not

less than three-quarters of a century, which had for years ceased to bear, or at best only now and then brought forth a small knotty fruit unfit for use. The tree had been dying branch by branch every year, until reduced almost to the original stem, with a few branches above. This tree appeared in the warm season to have renewed its youth. It was richly loaded with flowers and fruit, and gave hopes of an abundant product in the Autumn. It suffered, however, like the others from the storm; very few of the blossoms or young fruit remaining still attached. One of these went on to full size; and the handsome Newtown pippen which I now exhibit to the members as the sole relict of the storm, shows what the product might have been had not the hail interfered.

I consider that the efficiency of potassa in the revival of fruit trees has been satisfactorily demonstrated by the foregoing experiments, at least in relation to the peach and apple trees, and I may add also the pear and quince, several of which were treated in the same way and with similar results.

As to the securing of the plum and other fruits against the curculio, I think it highly probable that this also may be done by ashes, on the principle already stated, but I can adduce no proof of the fact; for, in the only instance in which ashes were applied to a plum, though the tree showed its effects by a copious growth of leaves and flowers, and even of young fruit; yet the destruction of these by the hail storm prevented the completion of the experiment; and for the determination of this point, which is an important one, we shall have to wait another year.

But, important as I consider the discovery of the reviving power of potassa in the case of failing fruit trees, I attach much greater value to its influence in another direction, which has suggested itself in the prosecution of the foregoing experiments. It is an unfortunate fact, with which the farmers of my own country neighbourhood are unhappily but too familiar, that certain cereal crops, especially that of wheat, have for some years failed to be remunerative. Where wheat formerly yielded 20 bushels or more to the acre, it can now seldom be made to produce more than 12 or 15 bushels.

In examining into the relative proportion of potassa contained in the ashes of different plants, I was surprised to find that, while the ashes of the common fire wood, as the oak, maple, &c., contain from about 2 to 4 parts in 1000, the wheat stalk yields 47 parts. Now, while this fact shows the extraordinary demand of growing wheat for potassa, it suggests also that the failure of this crop of late may be owing to the same deficiency of the salts of potassa in the soil which has caused the premature destruction of the peach; and, though the manure employed in the cultivation of wheat contains potassa, yet it does not yield as much of this alkali as the plant requires for its greatest productiveness; few of the vegetables that unite in the constitution of manure containing so large a proportion as wheat. To meet this demand of wheat, I propose to employ unleached ashes in the cultivation of this cereal. Leached ashes, though containing but a small proportion of potassa, and that chiefly in the form

of insoluble silicate, have nevertheless been found one of the best fertilizers for wheat; and the unleached, if properly applied, would probably produce a much greater effect. This is as yet conjectural; but I have instituted an experiment which I hope may determine the point.

In the early Autumn I caused an acre of ground to be prepared for a wheat crop. It was divided into three parts, one of which was to be treated with fresh ashes exclusively, another with ashes and swamp muck, and the third with muck alone. The part treated with fresh ashes exclusively was first ploughed, and then sown with wheat and ashes, and finally harrowed; the ashes being applied to the surface, so that its potassa when dissolved by the rain should be in immediate contact with the germinating seed; instead of being ploughed in, as ordinary leached ashes are. The second part, after being covered with the muck, was ploughed; and the wheat and ashes were applied as before. The third part was simply treated with muck, then ploughed and sown with wheat.

The result of this experiment cannot be determined until the time of the wheat harvest next Summer; but, thus far, it is decidedly in favor of the ashes; the two-thirds which were treated with this material being obviously better grown than the part treated with muck alone. A glance of the eye is sufficient to show a decided line of demarcation, the ashed part being greener and further advanced than the remainder.

I have little doubt that the same remarks are equally applicable to the common potato. This is now a much less certain, and on the whole much less productive crop than formerly. I find that the potato stalks contain 55 parts of potassa in 1000 of ashes; so that the plant requires considerably more potassa than wheat. If, therefore, fresh ashes are to be a remedy for the failure of the wheat crop, they are likely to be even more so for the potato. The verification of this supposition experimentally I have reserved for the next year, when, if living, I propose to try an experiment on a large scale.

An objection to all the foregoing facts, in a practical bearing, is the question whence the ashes are to be obtained for carrying the proposition into effect on a large scale, and whether enough can be obtained for the purpose. An obvious answer to this objection is that, should ashes fail in any neighbourhood, recourse can be had to the crude potash of the shops derived from the lixiviation of the ashes of forests cleared in the course of cultivation, and, when these forests shall have all been destroyed, we may resort to the minerals containing potassa, as to the felspar in granite rocks, which contains a large proportion of that alkali.

But for a long time yet to come, and indefinitely as regards fruit trees, ashes can be obtained from the resources of the farm itself. If all the falling leaves of the woods and swamps, all the dead and dying branches or stems of trees, and all the weeds, trimmings of trees, and other rubbish of a farm be collected and burnt, enough ashes could probably be obtained annually, for an indefinite length of time, to keep all the fruit trees in full bearing.

Stated Meeting, January 20, 1871.

Present, twelve members.

GEO. B. WOOD, President, in the Chair.

A letter was received from the Illinois Industrial University at Champaign, dated Jan. 12, 1871.

Letters of envoy were received from the R. Saxon Society, and the Society of Natural Sciences at Chemnitz.

Donations for the Library were received from the Royal Academies and Societies at Berlin, Leipsig, Munich, Chemnitz, Altenburg, Quebec and Montreal; the London Astronomical, Antiquarian and Meteorological Societies; the American and Medical Journals, Prof. Greenough of Cambridge, Dr. D. D. Slade of Chestnut Hill, Mass., Prof. E. B. Andrews of Columbus, Ohio, and Gen. Tyndale.

The death of Stephen Colwell, at Philadelphia, Jan'y 15th, aged 70 years, was announced by Prof. Cresson; and on motion, Mr. Carey was appointed to prepare an obituary notice of the deceased.

The death of Dr. Edward Rhoads, at Philadelphia, Jan'y 15th, aged 29 years; was announced by Professor Trego.

Mr. Lesley was elected Librarian.

The Committee to which was referred the paper of Dr. Pepper, on a case of universal Hyperostosis, reported in favor of its publication in the Proceedings of the Society, accompanied with figures for two octavo plates, which, on motion of Prof. Cresson, was so ordered.

A communication entitled: "Computation of the effects of gradients, by Herman Haupt," was read by the Secretary.

COMPUTATION OF EFFECT OF GREDIENTS, by HERMAN HAUPT, C. E.

(*Read before the American Philosophical Society, Jan.* 20, 1871.)

When the maximum load of the same engine on any two different inclinations has been determined by experiment, the data thus furnished will suffice to calculate the load on any other inclination, the load on a level, the angle of friction at which a train will descend by gravity, the tractive power per ton of load required on a level, and the number of pounds adhesion for each ton of load.

Let R = resistance of the train on a level, which is equal to the power of the engine.

W = gross weight of train on a level.

W^1 = Weight of train on grade a.

W^2 = Weight of train on grade b.

It is proper to assume that the power required to move a train and the resistance, which is equal to it, will be in proportion to the gross weight.

The force of gravity on any inclination is in proportion to the height of the plane divided by its length, or as the rise per mile divided by 5280.

The resistance of the train W^1 being in proportion to its weight, will be expressed by $\frac{W^1}{W}R$

and the resistance of W^2 by $\frac{W^2}{W}R$

The gravity of the train W^1 on the grade a = $\frac{W^1a}{5280}$

and of the train W^2 on the grade b = $\frac{W^2b}{5280}$

If the engine is supposed to be loaded to the limit of its capacity on each gradient, then the power exerted must be the same as on a level and

$$\frac{W^1}{W}R + \frac{W^1a}{5280} = R$$

$$\frac{W^2}{W}R + \frac{W^2b}{5280} = R \quad \text{and consequently}$$

$$\frac{W^1}{W}R + \frac{W^1a}{5280} = \frac{W^2}{W}R + \frac{W^2b}{5280}$$

From which the value of R in terms of W W^1 and W^2 is found.

$$R = W\frac{W^2b - W^1a}{5280\ (W^1 - W^2)}$$

Take now the former equation $R = \frac{W^1}{W}R + \frac{W^1a}{5280}$

from which a second value of R is obtained $= \frac{W\ W^1a}{5280\ (W - W^1)}$

Placing these two values of R equal to each other, there results $\frac{W^1 a}{W - W^1} = \frac{W^2 b - W^1 a}{W^1 - W^2}$

By substituting in the equation the values of W^1 W^2 a and b, as determined by observation, the values of W, or the gross load on a level can be ascertained.

By substituting the values of W W^1 W^2 a and b, the value of R on the power exerted by the engine is obtained.

By dividing this power in pounds by the gross load on a level, the tractile power per ton is determined.

As the power of an engine is always sufficient to slip the wheels on a dry rail, the adhesion is equal to the actual power exerted in moving the train and divided by the weight on drives, gives the proportion between adhesion and weight.

The angle of friction can be found when the tractive power per ton of of 2000 lbs. on a level (T) has been determined, by the equation.

Angle of friction expressed in feet per mile $= \frac{T \times 5280}{2000}$

It has been customary for engineers to consider the angle of friction as 16 to 18 feet per mile, the tractive power per ton on a level 8 pounds, and the adhesion one-eighth the weight upon the drives; but to obtain reliable data from the actual operation of roads running full trains, a letter was addressed to A. J. Cassatt, Gen'l Sup't of the Penna. R. R., who furnished the following data:

A standard 10 wheel freight engine with 3 pairs of 4½ feet drivers with average water and coal, weighs			75,500 lbs.
Weight on drivers,			53,000 "
Weight of tender with coal and water,			50,000 "
Such an engine will haul on a moderately straight and level road 50 loaded cars of 40,000 lbs. each.		Gross load,	1062 tons.
On a grade of 10 feet to the mile,	43 cars,		922 "
" " 26 " " "	35 "		762 "
" " $52\frac{8}{10}$ " "	17 "		402 "
" " 96 " " "	11 "		282 "

And the engine would work easier with 50 cars on the level than in either of the other cases and with most difficulty in the last.

Herman J. Lombaert, Esq., Vice President and former General Superintendent of Penna. R. R., gives as a full average load for actual work in the usual conditions of the rail.

			Tons.
Load on $52\frac{8}{10}$ ft. grade,	16 cars.	Gross load of engine,	382
" " 10 " "	40 "	" " "	862

As it is proper to allow a margin for unfavorable condition of rails, the calculations will be made on the data furnished by H. J. Lombaert.

Substituting the values of a b W^1 W^2, which are 10, $52\frac{8}{10}$, 382 and 862, the value of W, or the gross load on a level is found be 1210 tons.

The value of R or the tractive power on a level, is 11,160 lbs., or $9\frac{2}{10}$ lbs. per ton.

The angle of friction is $\frac{9.2 \times 5280}{2000} = 24.28$ feet per mile.

The adhesion is $\frac{11,160}{53,000}$ or nearly one-fifth of weight on drives.

From the data thus obtained a simple formula may be found to determine the load of the engine on any given inclination, a.

Let P = tractile power of engine on a level = 11,160 lbs.

a = feet per mile of inclination.

W^1 = weight of train on incline a, including engine and tender.

Then $W^1 \times 9.2$ = power required to move W^1 on level.

And $W^1 \frac{a}{5280}$ = gravity on incline a, in tons or $W^1 \frac{2000}{5280}$ a, in pounds.

$9.2\, W^1 + \frac{2000}{5280} W^1 a$ = power of engine = 11,160 lbs.

Or $W^1 = \frac{11,160}{9.2 + .38a}$

If a be supposed equal to 48.56, or twice the angle of friction, the load would be 404 tons nearly, or one-third the load on a level.

On a grade of 30 feet the load would be 541 tons. The grade that would require double the power of a grade of 30 feet would be $84\frac{1}{2}$ feet.

If the gross load of a train on a grade of 30 feet be 541 tons, the engine and tender being 63 tons, the cars and contents will weigh 478 tons, or if 18,000 lbs. be allowed for each car and 22,000 lbs. for load, the number of cars will be 27 and the net load 297 tons, weight of cars 243 tons.

If the return cars shall be only one-fourth loaded, which is probably a full proportion for the Shenadoah Valley extension, the gross weight of the trains would be 380 tons.

The inclination that would employ the full power of the engine in hauling 380 tons, would be 53 feet.

The inclination that would employ the full power of an assistant engine in hauling a gross load of 380 tons, would be 130 feet, but allowance must be made for the weight of the assistant engine.

The following description of Indian sculpture on the banks of the Monongahela River, by Jos. D. Reid, was received through Prof. Cope, accompanied by a drawing of the same.

SKETCH AND DESCRIPTION OF A CARVED ROCK *on the bank of the Monongahela River, Pa.*, by JOSEPH D. REID.

(*Read before the American Philosophical Society*, Jan. 20, 1871.)

The engraving represents the face of a large rock lying on the east bluff of the Monongahela River, in Fayette County, Pennsylvania, opposite the village of Millsborough and the mouth of Ten Mile Creek.

Originally there were three rocks, but after the settlement of the country, two of them were broken up and used in building a mill dam. At that time no one valued or took any interest in them, so no record was kept other than the fact that they were larger, and the figures more numerous than on the one remaining. This is in its original position, partly buried in the earth and so worn by the elements that the figures have become indistinct, and some perhaps entirely obliterated.

The Indians that inhabited this part of the conntry at the time of its settlement by the whites, had no legend connected with the rock, nor had they used it for any purpose. The river bank at this point and for a mile above and below is nearly a perpendicular bluff, three hundred feet high, which is broken by a single ravine, and up this by a narrow winding path, apparently made by the same people that carved the figures on the rock, it may be reached directly from the river. A carriage road that leaves the river opposite Fredericktown, and winds around behind the bluff, passes within a few hundred yards of it.

The rock is sandstone, of the same formation as that overlying the coal bed below; the surface is nearly flat, of an area of twenty by twenty-four feet, with a depression diagonally across, in a line with the three cups or hollows, the largest of which is one foot in diameter, the middle one six inches, and the other three inches, and about the same in depth. The depression or gutter and cups, are discolored, apparently by the blood of the victims that the inhabitants offered as sacrifices to their deity.

The south end of the rock is three feet above the ground, with a hog-like figure carved upon it. The foot and hand prints are deeper and more perfect than the other figures, and in no way can I better describe them than they present the appearance of having been made by pressing the naked feet and hands upon soft clay, so perfect are some of the impressions. This is particularly the case with one foot-print, with a large toe on each side of the foot, and a hand-print with a thumb on both sides.

The largest impressions of feet measure fourteen. inches in length, eight inches across the toes, and four inches across the heel, the other foot-prints vary in size from that of a full grown man to a child five years of age; the foot-prints of squirrels are numerous and cross the rock in every direction, not all that were on the rock being represented in the engraving. A single track of an animal with claws, and one intended to represent a buffalo track, but too small and no division of hoof, are also on the rock. The bird tracks are quite distinct and six inches in length; the three links have apparently been made recently. The other figures are outlines, and whether made as a pastime by some Indian artist or as the hieroglyphic history of an Indian race, I leave others to determine.

Two miles down the river from the rock is the site of an old Indian town and grave-yard, which covers an area of fifteen or twenty acres. There may be found pieces of sun dried pottery made of clay and minute fragments of muscle shells, pipes of the same material, and some of soap stone, axes of red ?jasper as hard as steel, arrow heads of flint, and circular flat sandstones, two of six inches in diameter and from one-fourth of

an inch to one inch in thickness, some of them with a hole in the centre and with a worn appearance of the edge.

The graves are covered with flat stones taken from the cliff above the town; they were placed about two feet below the surface, and being out of reach of the plow, the graves are seldom disturbed; one opened a few years since, exposed the skeleton of a female in a sitting position with a child in her arms, the skull of the child stuck to the stone, and when exposed to the air for a few minutes a slight puff of wind carried it away in a little cloud of dust. The skeletons are found in a sitting position facing the east and after being exposed a short time fall to dust. Nothing besides pieces of charcoal have been found in the graves with the bones. (See Plate I.)

The following members were nominated and elected to serve on the Standing Committees for the year:—

Finance.—Mr. Fraley, Mr. E. K. Price, Mr. Marsh.

Publication.—Prof. Trego, Mr. E. K. Price, Dr. Carson, Mr. Fraley, Mr. W. M. Tilghman.

Hall.—Gen. Tyndale, Mr. E. Hopper, Mr. S. W. Roberts.

Library.—Dr. Bell, Dr. Coates, Mr. E. K. Price, Dr. Carson, Dr. Krauth.

On motion of the Secretary, the reading of the list of members was postponed to the next stated meeting.

Pending nominations Nos. 661 to 668, and new nominations Nos. 669, 670, were read.

Balloting then proceeded; and there being no other business, the ballot-boxes were examined by the presiding officers, who declared the following named persons duly elected members of the Society:

M. Esquirox de Parieu, of France.
Mr. W. T. Roepper, of Bethlehem.
Rev. W. C. Cattell, of Easton, Pa., Pres. Lafayette Coll.
Mr. H. M. Phillips, of Philadelphia.
Mr. Thos. Meehan, of Germantown.
Gen. George G. Meade, of Philadelphia, U. S. A.
Lieut. C. E. Dutton, of Frankford, Pa.
Mr. Ed. Goodfellow, of Philadelphia, U. S. Coast Survey.

And the Society was adjourned.

Stated Meeting, February 3, 1871.

Present, twelve members.

MR. FRALEY, Vice President, in the Chair.

Mr. Goodfellow, a newly elected member, was presented to the presiding officer, and took his seat.

Letters accepting membership were received from Mr. W. Thos. Roepper, dated Bethlehem, Jan. 30; from C. E. Dutton, Lieut. of Ordnance U. S. A., Frankford Arsenal, Jan. 30; from Thos. Meehan, dated Germantown, Jan. 26; from W. C. Cattell, dated Lafayette College, Easton, Pa., Jan'y 23; from Edward Goodfellow, dated 927 Clinton Street, Phila., Jan'y 23; and from Geo. G. Meade, Maj. Gen. U. S. A., dated Phila., Jan'y 30, 1871.

A letter was received from Wm. Lowber, M. D., dated 319 S. 16th Street, Phila., Jan'y 8, 1871, offering for the acceptance of the Society the glass cylinder of the electrical machine belonging to his great-grandfather, David Rittenhouse, an early President of the Society. On motion, the offer was accepted, and the Curators were desired to return to Dr. Lowber the thanks of the Society.

A letter was received from Wm. Hitchman, M. D., dated 29 Erskine Street, Liverpool, Eng., January, respecting the organization of a Liverpool Anthropological Society.

Donations for the Library were received from the Italian Committee of Geology, the Academia dei Lincei at Rome, the Berlin Academy, the London Astronomical Society, the Essex Institute, the Boston Natural History Society, the American Journal of Science, the Franklin Institute, Penn Monthly, Pennsylvania Institution for the Blind, American Journal of Pharmacy, and London Nature.

The death of George Ticknor, of Boston, a member of the Society, Jan. 26th, aged 80 years, was announced by the Secretary.

On motion, Dr. H. Hartshorne was appointed to prepare an obituary notice of the late Dr. Rhoads.

On motion, Prof. Kendall was appointed to prepare an obituary notice of the late Prof. Chauvenet.

Mr. Cope reported that Mr. McNeil was prosecuting his researches in Panama, and had sent home fossils, showing among other things, that the back bone or water shed of the Isthmus was an ancient coral reef, many of the corals being in an excellently well preserved condition.

THE PORT KENNEDY BONE CAVERN.

Prof. Cope announced the discovery of a bone cave by Mr. Charles M. Wheatley, in the Calciferous limestone, at a point about 25 miles N. W. of Philadelphia.

There had been obtained numerous remains of plants, and insects, with about thirty species of *vertebrata.*

These consisted of Reptiles, Birds and Mammals. The first were serpents, and tortoises of several species, mostly harmless. The birds included a turkey and snipe. The mammalian remains were most numerous, embracing various forms.

There were *Rodentia,* of American types, as *Hesperomys, Fiber,* etc.; also *Sciurus, Lepus,* etc.

There were Ruminants, several tapirs, and a small horse. Two carnivoxes of large size, one a cat, the other a bear, *Ursus pristinus* of Leidy, of a remarkable type, and entirely distinct from the cave bear, or living species of Europe and America. Remains of several Sloths were discovered, which were mostly of gigantic size. These were referable to at least three species, one *Megalonyx wheatleyi* was new, and two *Mylodons,* one of them probably also new to science. With them occurred the teeth and tusks of the *Trilophodon ohioticus* (Mastodon). This animal had probably fallen in, as the cave was rather a fissure at the point examined.

The bones were not gnawed. The fissure was 40 feet deep, 15 feet in width, and of unknown length. Above the cave deposit, it was filled with wash from neighboring hills of Triassic age.

Mr. Lesley desired to place on record the recent exposure of a bed of solid brown hematite iron ore, at the upper limit of No. II, Lower Silurian Limestone Formation, in Leathercracker Cove, Morrison's Cove, Middle Pennsylvania, of very unusual size. The bed is nearly vertical and 72 feet thick, where cut across by a water drift. No such deposit has been before discovered at this horizon, in a situation favorable for exact measurement.

Pending nominations 669, 670 were read, and the reading of the list of members was postponed, and the Society was adjourned.

Stated Meeting, February 17, 1871.

Present, ten members.

MR. FRALEY, Vice President, in the Chair.

Mr. Carey accepted by letter, the appointment to prepare an obituary notice of Mr. Colwell.

Letters of acknowledgment were received from the New York, New Jersey, and Georgia Historical Societies (85); Cincinnati Observatory (85); Smithsonian Institution (84 and XIV. 2), and Reichenbach N. H. Society (78, 79, 80).

Donations for the Library were received from the Royal Academy and Observatory at Turin, Levant Herald at Constantinople, London Nature, Philadelphia Journal of Pharmacy, Medical News, McCalla & Stavely, the Librarian of Congress, and the Wisconsin State Historical Society.

No. 85 of the Proceedings, just published, was laid on the table.

The death of John F. James, a member of the Society, at Philadelphia, Feb'y 5, was announced by the Secretary.

Mr. Lesley asked for information respecting the alleged discovery of a hewn cave and crypt with hieroglyphics, skeletons, vases, &c., lately made by a railroad engineering party

in Iowa: and connected it with Baron Burck's account of the traditions he found among the Aztecs, of the migration of that race or tribe from the Northeast or Upper Mississippi and Missouri country.

Mr. Coxe described a locality at Baker's Run, on the West Branch of the Susquehanna, where the great freshets of 1863 uncovered ancient hearths and numerous large vases, all of which were soon broken and scattered by the curious.

The minutes of the last meeting of the Board of officers were read.

Dr. Emerson introduced the subject of Lunar Influence, or supposed influence, upon the conditions of wet or dry weather.

On Lunar Influence *upon the Conditions of Wet or Dry Weather*, by Dr. Emerson.

(*Read before the American Philosophical Society, February* 17, 1871.)

That the moon exerts such an influence, he said, is a very old opinion, widely spread at the present day, and even maintained by many distinguished philosophers. A great deal of attention has been devoted to tabulating atmospheric observations in relation to the conditions of the weather at the quarterly changes of the moon. The results of such laborious investigations have, however, not been found to agree, some reports seeming to favor the existence of lunar influence in producing wet and dry weather, and others, to show that no such influences are exerted by the moon upon the hygrometric conditions of our atmosphere. Among the many who have engaged in investigating this subject I will only refer to the celebrated Italian philosopher Toaldo, whose observations were extended through a period of forty-five years, and to Pilgram, whose observations were extended through a period of fifty-two years. For some reason which I shall not attempt to explain or examine, the conclusions of these indefatigable observers and inquirers *were the very opposite of each other*. . .

The circumstance which has perhaps contributed most to strengthen the belief in lunar influence upon the weather, is the well known agency exerted by the satelite upon the ocean and atmosphere, in the production of tides and barometrical fluctuations. Both of these phenomena are attributable to the force of *gravitation*, acting between the earth and moon, and giving rise to ocean and atmospheric waves.

The atmosphere surrounding our earth consists: first, of a mixture of permanently elastic gases; and secondly, of a changeable atmosphere of watery vapor, depending for its suspension entirely upon heat. This

theory of an independent atmosphere of vapor owing its suspension to heat alone, was established by Dalton, and is as incontestible as the theory of gravitation established by Newton.

When watery vapor suspended in the air loses the amount of heat necessary for its suspension, or, in other words, when the temperature is reduced to the "Dew-point," vapor is immediately condensed into mist, dew, clouds and rain. Now there is good reason to believe that the moon exerts no appreciable influence, directly or indirectly, upon the temperature of our atmosphere.

Some who have attempted to investigate this point by using reflectors and very delicate thermometers, have been led to the absurd conclusion that the moon's rays emitted cold. The marked depression observed in the thermometers exposed to the lunar rays, was in no wise produced by these, but by radiation of heat from the instruments into a clear sky.

In many parts of the surface of our globe, extensive regions exist in which it seldom or never rains, as in Lower Egypt. But in such places the atmosphere is very dry, and no local causes exist, such as mountains or hills, to interfere with the regular currents of the atmosphere and favor the mixture of strata of different temperatures. Consequently, rain rarely falls.

In other regions, in the Tropics, for example, there are extensive spaces in mid-ocean embracing many thousands of square miles, where the temperatures of the sea and atmosphere remain constantly within one or two degrees of each other, with the atmosphere of vapor close upon the "Dew-point." Here, if anywhere, the moon might be expected to produce changes in the hygrometric conditions of the atmosphere. But for months continued, there is no rain or other proof of lunar influence upon the weather. It is only in the extra-tropical latitudes where many other active agencies exist to disturb the equilibrium of atmospheric temperature, that the advocates of lunar influence assume to find evidence in favor of their views.

The power exercised by the moon upon bodies of water and permanent elastic gases on the surface of our planet, is solely derived from the law of *gravitation*, which exercises no influence, direct or indirect, in suspending or condensing vapor, or controlling the conditions of weather as to wet or dry. These conditions are brought about solely through changes of *temperature*, during the operations of which the moon remains a silent spectator, taking no active part, so far as the condensation of vapor is concerned.

Pending nominations 669, 670 were read.

On motion of Mr. Winsor, the Library Committee were instructed to report upon the subject of completing and publishing the Catalogue of the Society's books and pamphlets.

And the meeting was adjourned.

A CASE OF UNIVERSAL HYPEROSTOSIS, ASSOCIATED WITH OSTEOPOROSIS, WITH A DESCRIPTION OF THE SPECIMENS, by J. EWING MEARS, M. D., W. W. KEEN, M. D., HARRISON ALLEN, M. D., and WILLIAM PEPPER, M. D.

(*Read before the American Philosophical Society, Dec. 2, 1870.*)

The undersigned, to whom were referred the above specimens, presented by a friend to Dr. J. Ewing Mears, have carefully examined them, and have prepared the following Report:—

In the investigation of the subject, we have prepared as full a history of the case as could be obtained, a detailed account of the general anatomical characters of the disease, and of the peculiarities of each individual bone, as well as of the microscopic appearances, have consulted the works and periodicals in various languages accessible in this city, and have examined all the specimens contained in the Museums of the College of Physicians, Academy of Natural Sciences, University of Pennsylvania, Jefferson Medical College, and also the hospital and private collections in the city.

We have nowhere found specimens of this disease, or descriptions of such, at all equalling in extent and severity these here described.

The only similar case, though far less in degree and extent (skeleton imperfect), is found in Virchow's Archives, Vol. 43, 1868, p. 470, plate No. 12, although we have met with specimens and descriptions of skulls and bones which afford evidences of a limited development of the same disease.

Of the pathology of the disease, as well as of the anatomical appearances (116), we have found the best descriptions in Lobstein, Traité d'anatomie pathologique, Tom. II, p. 116; Boyer, Sur les Maladies, Chirurgicales, Tom. III, p. 571; Paget, Surg. Path. Eng. Ed., pp. 301–2, and fig. 40; Stanley on the Bones; S. Solly, Med.-Chir. Trans., Vol. 27; Förster Handbuch der Path. Anat., Bd. I, S. 249–52, and Bd. II, S. 850–4; R. Volkmann, in Pitha und Billroth's Handb. der Chirurgie, Bd. II, S. 249–58; Oeffinger, Virchow's Archiv, Bd. 43, S. 470; Haubner, Canstatt's Jahresbericht, 1854, Bd. 27, S. 23–4; Virchow, Die Krankhaften Geschwülste, Bd. II, Vorlesung XVII.

HISTORY OF THE CASE.

Fully recognizing the importance the history of the case has in the discussion of the Etiology and Pathology of the disease, we regret our inability to add any information to the statement given at the time of the presentation of the specimens, which is as follows:—

A. M. aet, 14, native of England—occupation farm boy—came from England to this country when very young—father died in November, 1862, of Phthisis, aged 57—mother died in 1867, cause of death not ascertained—has one brother and one sister, both young and healthy. In September, 1866, while engaged at work on the farm, noticed swelling

beginning in the face, and also, that in stooping, face felt puckered and wrinkled, while the effort to regain the erect position gave intense pain along the entire spinal column. Subsequently the fore-arms became sore and swollen, was placed under treatment, which was of such decided benefit that he thought himself entirely well, and in March, 1867, resumed his farm duties; about two months later the symptoms returned in an aggravated degree, the feet and then, in succession, the legs and thighs becoming enlarged and very painful; under the influence of constant bandaging the swelling diminished; his appetite became impaired, and he died from exhaustion Feb'y 8th, 1868. The treatment adopted was mostly of a tonic character.

DESCRIPTION OF THE SPECIMEN

(See Plates I. and II.)

I. WHAT BONES ARE WANTING.

We have the entire skeleton except the following bones:

Vertebræ—5th and 7th cervical.
1st and 10th dorsal.
2d lumbar.
2d and 4th sacral.
all the coccygeal.
Sternum, gladiolus and ensiform.
Hyoid bone.
Right Patella.
Hands, all wanting save the right scaphoid.
Feet, all wanting save left calcis.

Five metacarpal and metatarsal bones and eight phalanges are preserved, but, except the two metatarsals of the great toe, they can scarcely be designated, they are so greatly deformed.

II. THEIR CONDITION.

Unfortunately, by the prolonged boiling to which they were subjected before coming into our possession, the bones have lost probably all their animal matter, and are now almost as friable as if they had been burned. By removing the marrow, also, this has rendered the pathology of the disease much less clear and the microscopic examination much less valuable than it would otherwise have been. Moreover, it has removed probably all the gelatine, so that the chemical examination and the specific gravity would be worthless. Even the weights are, by reason of this misfortune, only of slight value. All the epiphyses too, except the coracoid process of the scapula, are separated from the shafts or bodies, and in some bones even integral parts are separated, *e. g.* the sacrum is divided into its component vertebræ and the innominate bone into two pieces. Many of the epiphyses are preserved, as will be indicated in describing each bone. The epiphyses have attached to them in many places the dried gelatinous articular cartilages of a transparent

brown color, and when an epiphysis has been incompletely ossified, the cartilaginous portion presents itself as a similar dried gelatinous mass. The ends of the shafts of the long bones are very ragged also, the cancellated substance being exposed and more or less broken.

III. WEIGHTS AND MEASUREMENTS.

In order to have some relative standard of weight, we have also weighed the bones of a girl of about seventeen. But, it must be observed, that all these but the scapula (which wanted the acromion epiphysis) were weighed with all the epiphyses. These healthy bones were rather slender, but were also longer than the diseased bones (the diseased and healthy femurs being 14½ and 16 inches respectively, excluding the lower epiphyses).

Diseased Bones.		*Healthy Bones.*	
Femur (without lower epiphysis)	8 oz.	Do (with all epiphyses)	8 oz. 3½ drms.
Tibia (" " ")	5½ "	Do " "	5 " 1½ "
Humerus (with all epiphyses)	3½ "	Do " "	2 " 3½ "
Radius (without epiphyses)	1½ "	Do " "	6 "
Ulna (without lower epiphysis)	2 "	Do " "	6½ "
Clavicle (" inner ")	½ "		
Scapula (" all epiphyses except coracoid)	1 "		
Fibula (without both epiphyses)	1½ "	Do " "	7½ "

The following are the measurements in circumference of the bones, the same healthy skeleton as before being used for comparison.

	Diseased Bones.	*Healthy Bones.*
Femur (middle),	5 in.	2½ in.
Tibia "	4¾ "	2½ "
(at tubercle),	5⅝ "	4⅞ "
Humerus (middle),	4¼ "	2 "
(above condyles),	5 "	3¼ "
Radius (middle),	3½ "	1¼ "
(lower fourth),	4¼ "	1⅞ "
Ulna (" and middle),	3½ "	1⅛ "
(just below corocoid),	4⅛ "	1⅜ "
Fibula (lower fourth),	1¼ "	1⅜ "
Clavicle (acromial extremity),	3¼ "	2⅜ "

The following are the diameters. In general the original limits of the bone were pretty easily distinguished. The external line of demarcation in the femur and the posterior in the tibia are so indistinct that the diameters of the original bones are not wholly reliable. All the diameters are derived from longitudinal sections by a circular saw, and they are all at the middle unless otherwise stated.

	Original Bone.	*Diseased Bone.*	*Addition by Disease.*
Femur,	1 in.	$1\frac{1}{2}$ in.	$\frac{1}{2}$ in.
Tibia,	1 "	$1\frac{9}{16}$ "	$\frac{9}{16}$ "
Humerus,	$\frac{3}{4}$ "	$1\frac{3}{8}$ "	$\frac{5}{8}$ "
Radius (middle),	$\frac{7}{16}$ "	$1\frac{1}{16}$ "	$\frac{5}{8}$ "
(upper third),	$\frac{1}{2}$ "	$\frac{7}{8}$ "	$\frac{3}{8}$ "
(lower third),	$\frac{3}{4}$ "	$1\frac{1}{4}$ "	$\frac{1}{2}$ '
Ulna (middle),	$\frac{7}{16}$ "	1 "	$\frac{9}{16}$ "
(at coronoid),	$\frac{5}{8}$ "	$1\frac{1}{4}$ "	$\frac{5}{8}$ "
(lower third),	$\frac{3}{8}$ "	1 "	$\frac{5}{8}$ "
Metacarpal (great toe),	$\frac{1}{2}$ "	$\frac{11}{16}$ "	$\frac{3}{16}$ "
Phalanx "	$\frac{7}{16}$ "	$\frac{11}{16}$ "	$\frac{1}{4}$ "
Clavicle,	$\frac{3}{8}$ "	$\frac{3}{4}$ "	$\frac{3}{8}$ "
Fibula (upper & lower thirds)	$\frac{5}{16}$ "	$\frac{3}{4}$ "	$\frac{7}{16}$ "
Ilium (1 in. above acetabulum),	$\frac{9}{16}$ "	$\frac{7}{8}$ "	$\frac{5}{16}$ "

IV. General Description.

The bones which have suffered the most are the clavicle, humerus, radius, ulna, femur, tibia, fibula, metacarpals, or-tarsals and phalanges of both hand and foot. These are diseased in almost the entire length of their shafts. The radius and ulna have suffered rather more than any of the other bones just named. All the other bones of the trunk have suffered to some extent, those of the skull but very little or not at all.

Comparing the upper and the lower extremities, there is no appreciable difference in the violence of the disease.

Comparing the two sides externally, not only is there no difference in the extent and character of the disease, but there is the most remarkable symmetry of the corresponding, diseased bones, which may be traced even to details. (Figs. 9 and 10.) The disease begins and ends on both sides at corresponding points, it changes in character from simple porosity to the growth of osteophytes at corresponding points; if on one side the posterior part of the bone is most diseased, the same is true of the other side; if the osteophyte growth is continuous or interrupted on one bone (fibula Fig. 18) it is so on the opposite one; if one is unusually diseased at a tendinous or aponeurotic insertion, so is its mate; if a groove or a variation in color exist on the one side, the same will be found on the other side; even of single marked spiculæ of bone the same may be said; so that a description of one side will answer for both, minute differences being noted as they occur.

The main violence of the disease is expended on the shafts of the long bones. The epiphyses, of which the most important remain, *e. g.* those of the femur, tibia, humerus, &c., show we may almost say no disease. The lower epiphysis of the femur is slightly porous in the usually compact layer of the articular surface, but so fine is the porosity and so slight the disease that it would not be observed save on a most careful examination.

The other epiphyses show occasionally still slighter disease. Indeed it is a question whether this be not the result of the prolonged boiling. The bones of the trunk are but little affected except the sternum, which must have suffered severely, the manubrium being very porous and much thickened. The bones of the head are scarcely at all affected.

The point of greatest development of the disease varies with its character. 1°. The thickening is most developed in the middle of the shafts, and here generally the sclerosis is furthest advanced. (Figs. 3, 4, 5, 21.) 2°. The porosity is not noticeably greater in any particular parts of the shafts, but seems externally to be equally diffused. 3°. The osteophytes follow a marked law in their development. They are most developed where the muscles, aponeuroses, fasciae, &c., are attached, *e. g.* the linea aspera, interosseus ridges of the tibia and fibula, radius and ulna, the insertion of the deltoid, biceps and brachialis anticus, the condyloid ridges of the humerus. But it is not always true conversely, that where a large muscle is attached there must be a large osteophyte growth, *e. g.* there are none at the origins of the pectoralis major and sterno-mastoid, the supra- and infra-spinatus, the insertion of the quadratus femoris, &c. One class of exceptions is, however, to be noted, viz: that at the attachment of those muscles and ligaments that are connected to epiphyses, there is generally no disease, *e. g.* the muscular attachments to the greater and lesser trochanters, the greater and lesser tuberosities, tubercle of the tibia, the tuber ischii and nearly all the ligaments. The epiphyses and their attached parts are very nearly all quite free from disease, though it may be largely developed in their immediate neighborhood.

The direction of the nutritious artery seems to have had no influence on the development of the disease either in its extent or degree.

The porosity varies in its character, and usually any one bone will show all its varieties. 1°. The surface of the bone presents a very fine cribriform appearance, resembling pumice stone. When magnified six or eight times this is seen to consist of a stout network of bone perforated by numerous small foramina, which are generally tolerably circular, and do not communicate one with another. (Fig. 24.) 2°. It may be of a finer velvety appearance. This by the same power is seen to consist of the same network of bone, whose very large foramina or meshes now communicate and are therefore very irregular in form, while the ridges forming the bony net-work are very thin and form relatively high walls between the adjacent meshes. Sometimes these ridges assume a tolerably regular parallelism, giving a striated appearance to the part. 3°. A coarser appearance is often produced by a similar honey-combing with large foramina or meshes, deep and irregular, varying in size from a horse-hair to a line in diameter with the first or second variety existing in the intervening ridges. (See lower end of Humerus, Fig. 1.) 4°. The surface is often pierced more or less sparsely by small foramina about the size of a horse-hair. (Fig. 20.)

The osteophytes vary greatly also in their character. In shape they

are either pointed, flat, or clubbed, sessile or pedunculated. They frequently form larger or smaller scales, which cover more or less of the bone. They vary from the smallest size visible up to $\frac{3}{4}$ inch in length or $\frac{1}{2}$ inch square. They are often compound, smaller ones growing from larger ones as a base. Imbrication is not unusually a marked feature, and whether imbricated or not, their direction or "trend" almost always follows that of the fibres attached at that point. This is very marked where adjacent muscles run in different directions, *e. g.* the flexor attachments of the radius and ulna as contrasted with that of the pronater quadratus. (Figs. 11 and 15.) The grooves between the osteophytes have sometimes rolling edges, sometimes are as sharp as if cut with a knife, and often lie closely together and parallel; they are apparently made in many cases by the numerous small vessels. All of the osteophytes are more or less porous.

The color is usually normal, but in some places is of varying shades of brown.

On a section the whole bone is seen to be encased with a new formation of bone. This is true not only of the long bones but also of the scapulæ and ossa innominata. Viewing these bones and also many parts of the shafts of the long bones on the surface, one would suppose he had simply to do with the original thickened bone which had undergone this porous change. But a section shows that there is a complete new formation which is added layer after layer around the old bone. These layers (excepting where sclerosis has taken place) are separated by interspaces sometimes just appreciable to the eye, sometimes a quarter of an inch wide. (Fig. 17). The outer layer is often very thin, but presents to the eye that deceptive appearance of apparent compact tissue which has simply become porous. Where sclerosis has taken place or osteophytes are developed, of course the thickness of the outer layer is either greatly increased or else undeterminable. The other layers also vary in thickness from the development of the sclerosis from the thinnest possible to one or two lines. "These layers may sometimes be traced into continuity with those forming the healthy portion of the wall" * of the original bone, especially at the extremities of the shaft. (Fig. 4.) At these points, starting from the original compact tissue, the several layers of the encasing new formation gradually become more and more widely separated or new layers may appear, thus producing a very great thickening at the centre, while at the ends of the shaft the thickening gradually (sometimes suddenly) diminishes. The interspaces between the layers are sometimes for even an inch wholly void, but they are generally filled with intervening trabeculæ of bone, which form a cancellated tissue and also support the superimposed layer to which they are always *perpendicular.* To a very large extent these layers have been welded together by sclerosis, and sometimes the new growth and the original bone present no line of demarcation by which they can be distinguished. Where this solidification has taken place, the cut surface instead of the uniform ivory-like solidity of normal compact

* Paget. Surg. Path. Eng. Ed. 1863, p. 301-2, and fig. 40.

tissue presents a granular appearance, as if the cancelli of the interspaces were not solidly filled up. The process of sclerosis not infrequently dips down like a cone whose base is of considerable extent at the surface of the new growth and whose apex just touches, or is sometimes welded with the original compact tissue. (Fig. 21.) Eburnation has nowhere taken place.

The original bone, too, has undergone marked changes. Its limits are generally pretty well defined, but the compact tissue of which its wall once consisted, is now cancellated, to a greater or less degree (osteo-spongiosis). Sometimes all appearance of compact tissue, save a mere worm-eaten porous external film, has disappeared. Sometimes no cancellation appears, but the old and new growths are welded together. The cancelli of the once compact tissue of the old bone always run *parallel* with the *axis* of the bone, and are thus easily distinguished from those of the spaces between the laminæ of the new growth which run at *right angles* to the surface of the bone. (Figs. 4 and 17.) The old cancellated tissue has often very large cancelli and in some cases has disappeared, leaving a wider medullary canal than is normal.

The epiphyses do not appear materially altered on section.

V. Description of Individual Bones.

1. *Head.*—All the bones of the head are present, completely disarticulated. The spheno-occipital suture was not ossified. No sections were made of these bones, and the external appearances alone are described.

(a) Frontal. The roof of the orbit, especially in the fossæ for the lachrymal glands, is somewhat porous. Internally the porosity appears over various parts of the perpendicular portion. The irregular striated appearance from large numbers of fine grooves is marked, and sclerosis seems to have made considerable progress.

(b) Parietal. Externally slightly porous at the posterior border; internally also over, say one-fifth of the surface, corresponding to the protuberance.

(c) Occipital. Externally small scattered patches of porosity; internally the same change is limited to the superior fossæ and the groove for the left lateral sinus.

(d) Sphenoid. Porosity of external surface of greater wings, and also in most of the pterygoid plates, which are somewhat thickened.

(e) Temporal. Slightly porous and thickened externally on squamous portion, and in the glenoid cavity and in the grooves for both lateral sinuses.

(f) Sup. Max. Slightly porous on anterior surface, and at the tuberosity. The alveoli are reticulated so as to resemble almost the meshes of the pulmonary structure.

(g) Palate. Internally, slight porosity at the junction of the perpendicular and horizontal portions.

(h) Inf. Max. Ascending ramus markedly thickened, and porous internally and externally; most developed at the centre of the ramus;

body similarly affected, principally between the mental foramen and the external oblique line. Alveoli like those of the upper jaw. This bone has suffered more than any other bone of the skull.

Condition of Teeth.—The teeth were all present, and were carefully examined. They were very brittle, so as to break across with little difficulty (see *Micros. Ex.*), but presented no peculiarity of shape. The entire absence of the peculiar deformity of the incisors, noted by Hutchinson, of London, as characteristic of hereditary syphilis, is to be especially marked as it bears upon the question of causation of the morbid process.

2. *Vertebræ.*—The epiphysal plates of the bodies, and the epiphyses of the transverse and spinous processes, are all gone. In the dorsal region the groove between the three original parts in which the ossification takes place, is very deep, but they are all united more or less. This groove gradually disappears both above and below, none of the remaining cervical vertebræ showing it, while inferiorily it is visible as far as the first sacral. On section the body is not much thickened, and no line of demarcation exists. No sclerosis has taken place.

(a) Cervical. Scarcely noticeable porosity of the anterior surface of body. Posterior arch of atlas is unusually thick and dense.

(b) Dorsal. Marked porosity of external surface of body, which is elevated above the surface left by the removal of the slightly overlapping epiphysal plates, about one-half a line to a line. Spinous processes slightly porous.

(c) Lumbar and Sacral. Same as dorsal; the porosity of spinous processes being more marked.

3. *Sternum and Ribs.*—(a) The manubrium only is present, and is very thick and porous. No osteophytes.

(b) The ribs have lost all their epiphyses. They are not affected on the external surface, save slightly in one or two instances. On the pleural surface they are all porous, and often a little thickened. For about one inch from the head the entire bone is thickened and porous.

4. *Upper Extremities.*—(a) Clavicle. The sternal epiphysis is wanting. Where the surface for the articulation with the acromion should be, there is on each side an oval cup-like depression $\frac{1}{2} \times \frac{1}{4}$ in. and $\frac{1}{8}$ in. deep. (Fig. 13.) Its walls are perpendicular, its floor flat, and both are covered with a thin layer of compact tissue resembling that which covers all the ends of the diaphyses of the other bones next the epiphysal cartilage. It was filled, when first seen, with a small mass of dried tissue resembling the epiphysal cartilage already described. Possibly it may have been an unusual third centre of ossification for this bone. It was occupied, certainly, by some substance separate from the shaft of the clavicle, either a third centre of ossification, or a projecting piece of the acromion. If the former, it is a very unusual place for a supernumerary epiphysis.

The whole bone is thickened to about twice its normal width, and its surface is coarsely porous throughout. At the insertion of the ligaments on the under surface, the porosity is quite fine and velvety. At the inner half of the origin of the deltoid there are twelve to twenty stout and well

developed osteophytes. A few also exist at the middle of the insertion of the trapezius. The section shows the original bone distinct from the new growth at all points. The laminæ of the new growth are very distinct at most points. A large part of those of the under surface are more or less closely united by partial sclerosis. The original bony tissue is relatively but little altered.

(b) Scapula. The coracoid process is one-third united to the bone, but wants the epiphysis developed on it at about seventeen years of age. All the other epiphyses are absent.

The bone is porous throughout, save at the centre of the infra-spinous fossa; generally of the coarse variety, but very fine in certain spots. The whole bone is somewhat thickened, as can be seen without any section, at its posterior border and on the spine. (Fig. 23.) The latter being to a great extent denuded of the outermost compact, yet porous layer of the new growth, shows the reticulated trabeculæ which supported it, and through their meshes the old external compact layer of the original bone now all worm eaten and very thin. This is especially well seen at the two extremities of the spine. The axillary border of the bone is three or four times as thick as is normal, has a few coarse osteophytes, and a very deep and wide groove for the dorsalis scapulæ artery.

(c) Humerus. All the epiphyses are preserved except that of the internal condyle. The trochlear surface projects only to a level with the radial.

The whole shaft (Figs. 1 and 2) is involved in the disease, the least at the upper fourth, the other three-fourths being about alike. The porosity is almost wholly very fine or velvety. About two inches below the head, at the insertion of the Pect. maj., the anterior bicipital ridge is greatly thickened (especially on the right side). It is continuous with a very large elevated surface ($2 \times 1\frac{1}{2}$ in.) at the insertion of the deltoid. This is covered with a large mass of not very large porous osteophytes whose trend is generally upwards. One (r. side) or two (left) large flat imbricated osteophytes mark the posterior lip of the bicipital groove. At the musculo-spiral groove, which is well marked, the bone is finely porous, but presents no osteophytes. At the lower third, anteriorly, the bone presents numerous osteophytes, sometimes single, but generally in groups. They are sessile, porous, and in some cases imbricated; their trend is generally downwards, except just above the epiphysis, where they are at right angles to the bone. The two condyloid ridges, especially the inner, are greatly diseased. The external ridge (especially on the right side) has several large porous sessile outgrowths with intervening grooves, the largest groove about corresponding in position to the anastomotica magna artery. The internal ridge up to the insertion of the coraco-brachialis is covered with large knobby and porous, imbricated osteophytes, continuous with a similar remarkable growth on the posterior surface of the bone, covering the origin of the internal head of the triceps, which extends to the musculo-spiral groove above, and fades into simple porosity externally. At the origin of the external head of the triceps, there is also a

marked elevation covered with pointed osteophytes, and continuous with that of the deltoid insertion. The trend of all these osteophytes is downwards, and their color (especially on the right side) is a light brown.

The section (Figs. 3 and 4) shows the outline of the old bone obliterated in the lower third, and only faintly visible in the upper two-thirds anteriorly. In the posterior upper two-thirds the laminæ of the new growth are admirably shown, though even here the sclerosis is in some parts far advanced. The original compact wall in the superior one-third, anteriorily, and two-thirds posteriorly, has almost disappeared, the cancellation (spongiosis) is so great, and it is a typical illustration of this process in various stages. The original cancellated structure is either fragmentary, its cancelli being very large, or else it has entirely vanished, leaving an enlarged medullary canal.

(d) Radius (Figs. 9, 10 and 11.) All the epiphyses are gone, save the left upper one. Instead of being rounded externally, and showing a sharp interosseous ridge internally, it is almost cylindrical, increasing in diameter from above downwards. At the bicipital tubercle there is a crest of curved osteophytes under which, as in a cave, the tendon of the biceps was inserted. The oblique line is marked by a series of knobby, porous, slightly imbricated osteophytes, whose trend is downwards and inwards till they reach the insertion of the pronator teres, where their size increases, and their trend is upwards and outwards. The interosseous border is rounded off and marked by a series of deeply imbricated laminated osteophytes, all trending downwards, resembling a rounded surface deeply grooved by oblique parallel cuts of a thin saw. Where the pronater quadratus was attached, a large number of osteophytes exist in ridges, which run laterally. All the rest of the bone is thickened and porous, and where the muscles took origin, is covered with porous osteophytes.

In section (Fig. 8) the outlines of the original bone are visible throughout; the laminæ of the new growth are marked; the sclerosis is in various stages, and anteriorly for some two inches the new and old growths are almost welded together. The old compact tissue is wholly changed to spongy, and the medullary canal is increased in size.

(e) Ulna (Figs. 14 and 15.) The lower epiyhyses are absent. Like the radius, the ulna is involved in its whole length, and is about twice its normal diameter. At the insertion of the brachialis anticus, a cup-like depression surrounded by an elevated ridge of osteophytes, exists, somewhat similar to that on the bicipital tubercle of the radius. The anterior surface is covered with small porous osteophytes, with a slight downward imbrication. At the attachment of the pronater quadratus they become more marked in their development, and the imbrication is external. The interosseus ridge is rounded off and marked, as in the radius, but with several unusually large and deeply imbricated osteophytes with a deep groove, probably that of the interosseous artery. Externally a brown discoloration is seen, which is the most noticeable on the right side. Posteriorly the bone is coarsely

porous, but very few osteophytes exist, save on the lower third. The intervening grooves run transversely, but are neither deeply nor sharply cut.

On section (Figs. 16 and 17) the line of the original bone can be distinguished throughout; the laminæ of the new growth are very marked; the sclerosis has welded together all the new layers anteriorly, and at the junction of the upper and middle thirds, the new and old growths are almost melted together both anteriorly and posteriorly. The interspace between the old bone and the first new lamina reaches one-fourth of an inch in width just below the olecranum, and the distinction between the perpendicular trabeculæ filling it up, and the longitudinal cancelli of the once compact tissue of the old bone is very marked. The medullary canal is scarcely, if at all, enlarged, and, indeed, at the point of greatest sclerosis above named, the same process seems to have invaded the canal itself.

5. *Lower Extremities.*—(a) Innominate Bones. The ilium is separated from the ischium and pubes, which are firmly and indistinguishably united together at their rami, but at the acetabulum are distinct. The Y-shaped piece uniting them is preserved, and is loose on both sides. All the other epiphyses are missing. The bones are porous throughout but not to a marked degree. The thickening varies from $\frac{1}{2}$ to $\frac{3}{4}$ of an inch, being greatest just above the acetabulum. On the ischium and pubes no osteophytes exist, save one small lamina on the body of the right pubes. The ilium is free from them except above the acetabulum for a considerable space, on and around the reflected origin of the rectus, where large and strong osteophytes exist, with a trend inwards and upwards.

On section of the ilium, (Fig. 12) the external surfaces, which otherwise would be thought to be the porous surface of the original bone, are seen to be the outer layer of the new growth. The original compact tissue has undergone spongiosis to a great extent. Sclerosis is furthest advanced just above the acetabulum.

(b) Femur (Figs. 6 and 7). All the epiphyses are separated. Both heads and great trochanters and the left lower epiphysis are preserved. The latter shows some very slight porosity, as already noticed.

Anteriorly the inter-trochanteric line is marked by a well developed growth of short, thick, rather acuminate osteophytes, separated by grooves running in the axis of the neck. A similar line of more slender imbricated osteophytes runs parallel to the base of the great trochanter and trends toward it. These two lines form the letter A. Immediately within this letter A (especially on the left side) the trend of all the osteophytes turns sharply downwards and so continues to the lower $\frac{1}{4}$ of the bone, where they are perpendicular. They are not very marked in their development. Just above the end of the shaft, however, they form an overlapping sheath to the bone. In the middle of the right femur an aperture ($1\frac{1}{4} \times \frac{3}{4}$ inches) exists in the ensheating new growth, disclosing

to view the original but altered bone. Posteriorly the osteophyte growth extends from half an inch below the lesser trochanter to within 2½ inches of the end of the shaft, and the same sheath-like appearance is very noticeable at its two extremities. Where not covered with osteophytes, the shaft is very finely porous and thickened. All the central two-thirds of the shaft is one vast mass of large, irregular, porous osteophytes. Their direction is not constant, but is in general downwards, and their shapes are very varied. The mass extends for about eight inches, along what was the tolerably sharp linea aspera, but is now about ¾ in. wide and about ⅜ inch thick. The posterior inter-trochanteric line and great trochanter are not affected, except a slight porosity in the former. The lesser trochanter is wanting, but for ½ in. around it there is no disease beyond some porosity save one squamous osteophyte on the right side.

On section (Fig. 5) in the axis of the head and great trochanter the outline of the old bone is not to be made out save internally, and then only imperfectly. The old and new growths are almost everywhere indistinguishably welded together. The laminæ of the new growth, too, are welded together save at a very few points. The old compact wall is still solid, but it looks granular and does not present the ivory-like solidity of normal compact tissue. The medullary canal is somewhat enlarged at the expense of its walls. At the lower extremity the trabeculæ of the cancellated substance are normal, but in the head and neck the arches for mechanical support are much less distinctly marked than is usual.

(c) Patella. The right patella is missing. The anterior surface of the left shows a few osteophytes trending downwards.

(d) Tibia. Both the upper epiphyses are preserved. The whole bone is greatly diseased and thickened to about twice its usual diameter. The tubercle is slightly thickened and presents a ragged edge above for articulation with the epiphyses, but the greater part of the tubercle being developed from the epiphyses the disease is not very marked. The crest is rounded in its whole length and porous. The internal sub-cutaneous surface presents marked swelling and porosity. There is but little osteophyte growth, and it is generally in the laminæ except at the sartorius insertion, where it is more developed. A number of deep grooves exist, generally longitudinal in their direction and most marked at the upper third. The posterior and external surfaces are covered with a warty growth of porous osteophytes which attain their greatest development at the interosseous border and especially at the oblique line. The general trend of all this growth is downwards. Grooves for the vessels are frequent and tolerably deep.

On section (antero-posterior) the outline of the old bone is distinct at the extremities, but in the central two-thirds it is barely visible in front and wholly lost behind, the sclerosis at this part having welded together all the laminæ of the new growth and the original bone. Even at the extremities the new laminæ are not very marked. The rarefaction of the original compact substance is of course therefore not marked. The medullary canal if at all altered is narrowed by the encroaching sclerosis.

(e) Fibula (Fig. 18). Its shaft alone is preserved, and its axis is slightly bent inwards. The whole bone is encased in a newly formed osseous growth which is sometimes simply porous, and is covered with sometimes an interrupted, sometimes a continuous, growth of warty osteophytes, all more or less porous. Posteriorly and internally this growth is most developed, the trend being downwards. The lower subcutaneous surface is greatly thickened and finely porous, but has no osteophytes.

On section the bone is doubled in its diameter, the outline of the original bone being only visible in about one-half of its extent, the sclerosis obscuring it at other points. The original compact tissue is rarefied by spongiosis, and the medullary canal is somewhat widened.

(f) Hand and Foot. They are considered together, as some of the bones are indistinguishable, and moreover, in general the same description applies to both.

(1.) Right scaphoid of hand. Not diseased.

(2.) Left calcis. Porous and enlarged throughout. Porous osteophytes are seen at the attachments of the tendinous sheaths internally, and one large flat one on the inferior surface. The epiphysis for the attachment of the tendo achillis is preserved, but shows no disease.

(3.) Metacarpus, metatarsus and phalanges. Two of the phalanges have their epiphyses attached but not united by ossification. The epiphyses are not diseased. No other epiphyses are preserved. All these bones suffer by far to the greatest extent in the centre, not at all at the head (viewed externally), and but little at the base, and the new growth is five or six times as thick on the dorsum as on the opposite surface. No osteophytes exist save on one of the metatarsal bones and at the ridges for the flexor sheaths of three of the phalanges.

On section (Fig. 21), compare also Fig. 22, the outlines of the old bones are very readily seen, the apex of the conical sclerosis having, at points, just touched the surface of the old bone. The original wall of compact tissue is wholly rarefied by spongiosis, and the cancelli of the new and old bone are readily distinguished by the different directions of their axes. The normal compact wall of the phalanges being very thick relatively, the changes in it are the more marked. Sclerosis has invaded from half to two-thirds of the new growth. The head of the bone is also markedly rarefied by spongiosis.

MICROSCOPIC EXAMINATION.

The specimens from which the following description and wood-cuts were made, were prepared with his well known skill by Dr. J. H. McQuillen. They consisted of a transverse section through the thickened wall of a phalanx, embracing the thickness of the layers superimposed by the periosteum, but not of the entire original compact layer of the bone, and of a transverse section through the right canine tooth.

The section of the phalanx (Fig. A) exhibited a quite compact osseous structure—the Haversian canals being for the most part round, and rather small, though in some places they were irregularly shaped or oval, and larger. The intervening bone lamellæ were of unusual thickness,

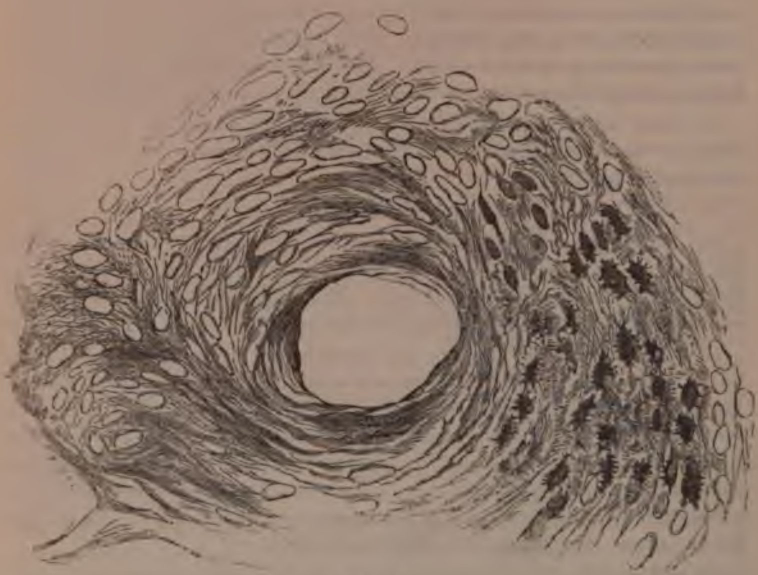


Fig. A.

and presented in the majority of cases, bone corpuscles with canaliculi. In some cases, however, no bone corpuscles were present, and the lamellæ appeared to be merely calcified by saturation with bone salts.

The bone corpuscles were small and often indistinct; in some places they were unusually round, but in others they presented the normal elongated shape; their canaliculi were invariably very poorly developed, and often could not be discovered.

With regard to the mode of arrangement of the bone lamellæ, they were always developed concentrically with (parallel to the walls of) the Haversian canals, and in no instance were any lamellæ found whose direction was parallel to the external surface of the shaft.

The section of the tooth (Fig. B) showed the existence of numerous irregularly shaped, branching lacunæ in the dentine near the marginal layer of enamel. These spaces were of various sizes and intercepted the

Fig. B.

course of a varying number of dental tubuli. They indicated unquestionably either an arrest of the process of calcification of the dentine, or of the resorption of calcareous matter already deposited, conditions which are also present in the true bony tissue. They are identical with the so-called *interglobular spaces* first described by Kölliker and carefully studied by Dr. McQuillen of this city, who has published (Dental Cosmos, N. S. Vol. VIII, No. 3, pg. 113,) several excellent illustrations of them.

PATHOLOGY OF THE DISEASE.

Having thus described the gross and minute features of these bones, we would hazard the following remarks in regard to the nature and cause of the pathological process :—

In the first place it is to be observed that three separate processes, or at least three distinct stages of the same process, are represented in different parts of the skeleton, or even, in some instances, in single bones. These stages are :

First. Internal Osteoporosis of the original osseous tissue. 2d. External Hyperostosis, due to successive attacks of Periostitis, both of which processes are present in varying proportion in almost all the bones, and 3d. Secondary Induration.

1. It is especially in regard to the explanation of the internal osteoporosis, which constitutes so marked a feature of these specimens, that we regret the absence of any careful examination of the bones in their recent condition. In their present state, it is only possible to describe the degree to which this rarefaction of the osseous tissue has occurred, but it is evident that such changes might be produced by very varied alterations of the medulla and bone corpuscles. Thus, among the recognized causes of osteoporosis, may be mentioned syphilis, scrofula, rheumatism; and, in addition, we must add that both osteomalacia and simple ostitis produce changes in the bones which, after the specimen has been boiled, and the organic matter entirely removed, are not to be distingushed from the effects of the first mentioned diseases. In each case, under the action of the morbid irritant, whether purely external and local, or internal and constitutional, there is more or less rapid proliferation of the essential vital elements of the osseous tissue, called bone corpuscles or cells. At the same time, the bony laminæ surrounding the Haversian canals, and the walls of the lacunæ, are progressively deprived of their calcareous salts and removed, while the enlarged spaces thus produced are filled by the constantly growing cellular elements. The manner in which this removal of the calcareous salts is effected has been, and indeed remains, a subject of much discussion. The first idea which seems to have been entertained may be inferred from the name, eccentric atrophy, which was given to many specimens of osteoporosis, under the belief that the bony lamellæ were thinned and pushed asunder by the centrifugal pressure of the growing medulla. There is, however, no evidence whatever in favor of such a mechanical explanation, and this hypothesis has justly been almost universally abandoned.

By far the most plausible explanation which has been advanced appears to be that the removal of the calcareous salts, the first essential step in the destruction of the bony lamellæ, is due to the solvent action of some acid elaborated by the bone cells during the inflammatory process. According to Weber, their removal is not due to the direct action of any acid, but is owing to a gradual conversion of the insoluble *tri-basic* phosphate of lime into the more soluble *bi-basic* salt.

As this feature of rarefaction is, however, common to so many diseases of the bones, it is evident that the most characteristic results of such diseases are to be rather found in the condition of the bone cells, and in the characters of the morbid product which has resulted from their multiplication. And it is to be trusted, that by careful chemical and microscopical study of these, such peculiarities will be discovered as will enable us to distinguish with certainty in recent bones the various morbid changes.

Heretofore the majority of observers have limited themselves either to a description of the dried bone, after maceration or boiling, or at most, of the general characters of the medulla with which its cancelli are filled. And it results from this superficial mode of study, that there is as yet but

little exact knowledge of the really essential changes which the organic, active portions of bones undergo in disease.

Virchow, who was among the first to examine microscopically the condition of the bone cells in ostitis and some other diseases attended with rarefaction of the bone tissue, (Über parenchymatöse Entzündung; Virchow's Archiv. Bd. IV. Hft. 2: 1852, b. s. 301 to 311,) formerly regarded the process as essentially a degenerative one, due to the fatty degeneration of the bone corpuscles and the subsequent softening and removal of the area depending on these cells. We have already, however, stated the view which appears most plausible in regard to the removal of the calcareous salts, and so far from fatty degeneration of the bone corpuscles being a constant feature in the different forms of osteoporosis, it would appear from the careful researches of Ranvier (Archives d' Anat. et Phys., Norm. et Path., No. 1, 1868, page 69), that this condition of the cells is altogether characteristic of caries and limited to that morbid process. On the other hand, there is every reason to presume that these cells are influenced by various morbid causes, (inflammation, syphilis, rheumatism, gout, scrofula, &c.) in the same way as the other tissues of the body, and give rise to products more or less characteristic of the diseased action present.

The history of the present case would appear to indicate that the nature of the disease was a rheumatic or scrofulous inflammation, but beyond this mere supposition we are prevented from advancing by the absence of any chemical and microscopical examination of the recent bones.

We would here again call attention to the marked peculiarity of the porotic bones, fully described at pages 24 and 25, and figs. 4 and 17, although we are unable to suggest any plausible explanation of the invariably parallel arrangement of the meshes of the porotic bone, and of the equally uniform vertical arrangement of the meshes of the new-formed sub-periosteal layers.

2. Another important appearance present in the bones here described, and indeed one which is as marked and wide-spread as the osteoporosis, is the extensive development of bone upon the exterior of the original shafts. In our description of the skeleton, we have already noted the peculiarities of these sub-periosteal growths, and it will be remembered that they are in every instance limited to the body or shaft of the bones, and never extend on to the epiphyses, and that they usually present several thin laminæ of imperfectly compact bone, parallel to the shaft and separated from it and from each other by more or less wide interspaces usually occupied by coarse cancellated tissue.

It is undoubtedly from the examination of such specimens as this that the mistaken idea arose that the lamellæ, of which the original compact shaft was formed, had been pushed asunder by the great enlargement of its cancelli. It will, however, be seen from our description that the ap-

pearances contradict any such supposition, and clearly show that while in the cancellated and imperfectly compact tissue of the original shaft a process of rarefaction (osteoporosis) has been advancing by atrophy of the bony lamellæ, there has also been an active process of periostitis resulting in the formation of thick layers of new bone on the exterior.

Another means of distinguishing the line of demarcation between the original shafts and the new-formed layers, is the abrupt change in the direction of the cancelli already referred to.

It is evident, also, that the periostitis has not been uniformly continuous, but that for a variable time its intensity was such that the inflammatory product was capable of but imperfect ossification, and remained as cancellous tissue; while at irregular intervals thin layers of imperfectly compact tissue have been formed. The occurrence of this long standing, but not uniform process of periostitis ossificans appears to account, in every instance, for the changes observed on the exterior of the original shafts. In addition to this uniform hyperostosis, it will be observed from the description (see pp. 23, 24) that the same process of periostitis has given rise to varied forms of porous osteophytes.

3. In some places, however, it is evident that a still further change has occurred, consisting in the gradual conversion of the cancellous tissue into compact bone. This process of consecutive or secondary induration is most marked in the layers of bone formed by the periosteum; though it is present in the shafts of the tibiæ, femora and some other bones. It is manifestly impossible to determine accurately the portions which have been rendered compact by this process, but the disposition of the successive layers of new-formed bone is, in general, so much like that above described, that we are inclined to regard all the areas of compact bone of any considerable thickness as due to this secondary change.

It would, indeed, appear but probable that as the high degree of inflammation, under which the layer of cancellous tissue had been formed, subsided, there should be a tendency to the formation of successive layers of bone on the interior of the walls of the cancelli. It is especially in connection with this point that the result of the microscopical examination of the sub-periosteal layers is of so much interest. It will be observed (see Fig. A) that in the newly-formed compact bony tissue, the lamellæ are arranged concentrically around the vascular canals; a mode of arrangement which strongly points to the occurrence of the process of consecutive induration, as we have above described.

The specimens are deposited in the Museum of the College of Physicians.

J. EWING MEARS, M. D.
WM. W. KEEN, M. D.
HARRISON ALLEN, M. D.
WM. PEPPER, M. D.

Stated Meeting, March 3, 1871.

Present, five members.

Dr. G. B. Wood, President, in the Chair.

Donations for the Library were received from the Dorpat Observatory, St. Gall Society, R. Asylum for Lunatics at Perth, Scotland, the London Royal Society, R. Geographical Society, Society of Arts, and Thomas Irving, Esq., General Sabine, Sir Charles Lyell, the Royal Observatory at Greenwich, Prof. Mayer of Bethlehem, the American Pharmaceutical Association, Franklin Institute, Directors of City Trusts, and U. S. Commission Bureau for the Paris International Exposition for 1867.

The Cylinder presented by Dr. Lowber was laid on the table, and Prof. Cresson called the attention of the members to it.

The death of Wm. J. Hamilton, F. R. S., member of the Society, was announced by Mr. Chase.

Prof. Cope offered for publication in the Proceedings three memoirs, entitled:

"Supplement to the Extinct Batrachia and Reptilia of N. America; by E. D. Cope." (See Proc. p. 41.)

"On two extinct forms of Physostomi of the Neotropical region; by E. D. Cope, A. M." (See Proc. p. 52.)

"On the occurrence of fossil Cobitidæ in Idaho; by E. D. Cope." (See Proc. p. 55.)

Also "Notes relating to the Physical Geography and Geology of, and the distribution of Terrestrial Mollusca in certain of the West Indian Islands; by Thomas Bland."

Prof. Cope exhibited specimens of teeth and portions of the jaw of a new Mososauroid; also slabs of coal slate, containing fossils of a new species of batrachian, and a new reptilian genus.

Mr. Chase offered some additional evidence of the contrast between European and American rainfalls; and communicated some American peculiarities in the relations of barometric pressure of winds and storms. (See below.)

Pending nominations Nos. 669, 670, and new nomination 671, were read.

Mr. Chase made a communication on the subject of providing suitable accommodations for the observations of the Signal Service Bureau, which was referred to the Curators and Hall Committee, with power to act.

And the meeting was adjourned.

European and American Rain-falls.

BY PLINY EARLE CHASE.

(*Read before the American Philosophical Society, March* 3, 1871.)

There is still a lingering skepticism on the part of some meteorologists, regarding the moon's influence on the weather, a skepticism which is perhaps owing to the apparent want of agreement between observations at different places. There is, however, no good reason for expecting such accurate correspondence as is sometimes deemed essential. Dr. Emerson (Proc. A. P. S., XI. 518) has communicated to the Society his early observation upon the reversal of the European barometric prognostics on this side of the Atlantic. Mr. Blodget (Climatology, pp. 221–237) has pointed out various climatologic contrasts, and Mr. Scott, the Director of the British Meteorological Office, has noticed an opposition between the solar (or temperature) rain-falls in Western Europe and Eastern America, analogous to that which I have indicated in the lunar rain-falls. The confirmation thus afforded to the results of my previous investigations, strengthens the presumption that, in our Atlantic States, signs of fair weather may be most confidently trusted during the ten days preceding, signs of rain during the eight days following, full moon.

In order to make a comparison between stations of similar latitude, I obtained from the "Observatorio do Infante D. Luiz," a record of the quarterly rains at Lisbon for sixteen years, which I have embodied, to-

gether with the observations at Pennsylvania Hospital for the same period, in the following tables. The measurements are given in millimetres.

I.—QUARTERLY RAIN-FALL AT LISBON.

YEARS.	WINTER.	SPRING.	SUMMER.	AUTUMN.	TOTAL.
1855	280.3	272.7	15.4	362.5	930.9
1856	513.4	300.7	8.5	90.3	912.9
1857	267.8	152.2	67.9	324.4	812.3
1858	224.2	113.2	7.1	567.6	912.1
1859	128.0	201.8	71.6	306.9	708.3
1860	210.9	122.4	39.6	187.3	560.2
1861	501.5	154.3	14.6	311.4	981.8
1862	364.4	282.9	6.6	176.9	830.8
1863	181.8	196.6	64.8	101.6	544.7
1864	155.3	282.2	33.9	363.5	834.9
1865	371.6	159.2	24.4	487.2	1042.4
1866	214.7	365.3	14.6	82.3	676.9
1867	197.2	216.2	13.6	172.1	599.1
1868	162.9	76.9	38.0	279.4	557.2
1869	323.2	158.5	3.1	66.0	550.9
1870	305.7	111.6	21.9	160.3	599.5
Mean	275.2	197.9	27.9	252.5	753.4

II.—QUARTERLY RAIN-FALL AT PHILADELPHIA.

YEARS.	WINTER.	SPRING.	SUMMER.	AUTUMN.	TOTAL.
1855	193.0	169.9	435.4	257.8	1056.1
1856	284.5	211.8	241.3	187.5	925.1
1857	184 4	359.9	482.6	133.4	1160.3
1858	264,9	272.8	274.1	227.1	1038.9
1859	376.7	376.9	376.4	371.6	1501.6
1860	240.3	229.6	311.7	342.9	1124.5
1861	269.8	362.5	243.3	332.0	1207.6
1862	292.6	254.5	263.1	343.9	1154.1
1863	280.7	442.0	297.4	153.4	1173.5
1864	174.8	448.3	204.2	327.9	1155.3
1865	370.1	374.7	291.9	380.3	1416.9
1866	390.4	247.9	194.6	370.9	1203.8
1867	230.1	370.6	742.5	228.1	1571.3
1868	225.3	401.3	268.0	404.6	1299.2
1869	318.5	296.2	247.7	337.8	1200.2
1870	297.7	404.9	303.8	195.8	1202.2
Mean	274.6	326.5	323.6	287.2	1211.9

It appears, therefore, that the heaviest rain-falls at Lisbon and the lightest at Philadelphia, are usually in the Autumn and Winter semester; the heaviest at Philadelphia and the lightest at Lisbon, in the Spring and Summer. In ten years out of the sixteen, when the rain-fall of the entire year was above the average at one station, it was below the average at the other.

American Weather Notes.

By Pliny Earle Chase.

The signal service observations of our War Department have already shown the value both of Buys Ballot's law and of Capt. Toynbee's modification in predicting changes of wind, especially if due regard is paid to the barometric variations of the two previous days. They have also suggested the following general deductions, some of which may perhaps prove to be true only of the winter, while others seem to be explicable by natural circumstances of position and physical configuration, which must be operative at all seasons.

1. Winds varying like the land and sea breezes, are often traceable, especially in the lull which follows the passage of storms, to differences of temperature in the neighborhood of the great lakes, and of mountain peaks and ridges.

2. The wind, especially in the Southern States, often blows directly in the line of the greatest barometric gradient. But even in such cases, after a few hours continuance, it tends towards the azimuth indicated by Buys Ballot's law.

3. The isobaric lines are, therefore, often of less relative importance than the gradients in forming forecasts.

4. Long ridges of high barometer, as observed by Espy and others, with adjacent troughs of low barometer, often traverse the continent, sometimes with slight deflection, sometimes having a semi-circular, circular, or elliptical curvature with a diameter of three thousand miles or more. Such ridges usually have a steeper declivity and stronger winds on their northerly and easterly than on their southerly and westerly sides.

5. Currents with an anti-cyclonic tendency, controlled by arreas of high barometer, are notably common. Reversals of wind, as from N. E. to S. W., are, therefore, frequent after the passage of an anticyclonic ridge or centre, as well as after the passage of a cyclone.

6. Our recent storms have been anticyclonic, and there seems some reason for supposing that anticyclones are the usual "weather-breeders," even of such of our land storms as become more or less cyclonic after they are fully developed.

7. The precipitation of vapor of course gives rise to local cyclones, which, however, may be easily and speedily overborne by the grand anti-cyclonic whirls of a half million miles or more in area.

8. These and other peculiarities, point to a probable origin of storms in the blending of polar and equatorial currents, near the latitudes at which the general tendency of the winds changes its direction.

9. Mr. Scott has observed that when polar (E.) currents are blowing at the North, and equatorial (W.) currents at the South, a serious barometrical disturbance, frequently resulting in a gale, generally soon follows; but when the polar current is at the South and the equatorial at the North there appears to be no law of sequence. The latter condition, with us, seems often indicative of approaching fair weather, especially if northerly or easterly are separated from southerly or westerly winds by a ridge of high barometer.

10. If the progress of a northerly or easterly current towards the equator is impeded by an intervening southerly or westerly current, the disturbance not only speedily follows, as indicated by Mr. Scott, but it is also, commonly, like most showers, S. E. storms, and other marked cyclonic commotions, of briefer duration than those which are primarily anti-cyclonic.

SUPPLEMENT to the "*Synopsis of the Extinct Batrachia and Reptilia of North America.*"

BY E. D. COPE.

(*Read before the American Philosophical Society, March 3, 1871.*)

BATRACHIA.

SAUROPLEURA REMEX, Cope.

Proc. Acad. Nat. Sci., Phila. 1868, p. 217. *O. amphiuminus*, Cope. Trans. Am. Phil. Soc. 1869, 17 in parts.

A fine specimen of this species recently sent me by Prof. Newberry, from Linton, Ohio, includes the vertebral column from the hind limbs to the end of the caudal series. One of the former is preserved and exhibits slender digits and other characters like those already described in the *S. pectinata*. Having ascertained that the *Oestocephalus amphiuminus* possesses no anterior limbs, I regard my reference of these species to that genus as premature, and will allow them to remain in *Sauropleura*, where I originally placed them.

OESTOCEPHALUS AMPHIUMINUS, Cope.

Trans. Amer. Phil. Soc. 1869, p. 17; l. c. p. ii.

The bones formerly regarded by me as referable to a rudimental fore limb in this genus, appear to be rather branchihyals, and indicate the existence of external branchiæ.

COLOSTEUS SCUTELLATUS, Newb.

Pygopterus scutellatus, Newberry, Proceed. Ac. Nat. Sci., Phil. 1856. *Colosteus crassiscutatus*, Trans. Amer. Phil. Soc. 1869, 23.

The original description of this species by Prof. Newberry was overlooked, in preparing my account of it above quoted.

MOSASAURIDÆ.

LIODON SECTORIUS, Cope, sp. nov.

Established on a large part of the under and upper jaw, and other parts of the cranium with a vertebra, from the green sand of the upper bed of the Cretaceous of New Jersey.

The character which at once distinguishes this species from other Liodons, and especially from all the species of *Mosasaurus*, is the very compressed form of the crowns of the teeth, which approach nearer in this respect to those of *Diplotomodon*, than any others that I have seen. The vertebra, a lumbar, has also subround articular faces, thus removing the species from close relationship to those with depressed vertebræ, of some of which the teeth are unknown.

In the present specimen crowns and pedestals of thirteen teeth are preserved. Those of the mandible are most numerous, and display the successional modification of form from before backwards visible in other species of the family. The anterior teeth are less compressed, and have

but one, an anterior, cutting edge, the posterior face being regularly convex. The inner face is much more convex than the outer, and the flatness of the latter is marked at the apex of the tooth by a short ridge which bounds it posteriorly. This is a trace of the bounding angle which extends to the basis of the crown in *Mosasaurus*. The anterior cutting edge is in profile convex; the posterior outline concave to near the tip. The cutting edge is acute, and beautifully ribbed on each side, but not properly denticulate. The surface of the tooth is not facetted, but the outer face exhibits the peculiarity of a longitudinal concavity, or shallow groove extending from the base to the middle of the crown. The enamel is polished, but under the microscope minutely and extensively striate ridged. This description is taken from the second or third from the anterior end of the maxillary bone. The third from the distal end of the dentary is very similar.

The crowns become rapidly more compressed as we pass backwards. From a broad oval section of two crown bases, we reach a flattened oval crown, with the cutting edge sharp behind as well as before, and minutely ribbed. The crown is not facetted, and is more convex interiorly than exteriorly. The exterior convexity is chiefly anterior; the posterior face is slightly concave from the open groove already described as present in the anterior teeth. In two posterior crowns, one still more elongate in section, the external concavity becomes flatter and includes a great part of the outer face. A tooth still more posterior presents the peculiarity of the species in the strongest light. The crown is still more compressed, directed backwards, and only .25 higher than wide antero-posteriorly at the base. The latter is a little over twice the transverse diameter just behind the middle. The surface presents the characters described in others. The outer concave surface is wide and shallow, and contributes to the attenuation of the posterior half of the tooth rather than the anterior, which is consequently thicker. The cutting edges are sharp, the anterior convex and retreating backwards to the rather obtuse apex; the posterior convex above, concave below.

The exposed parts of the dental pedestals are frustra of cones, neither swollen nor concave.

Measurements.	*M.*
Third superior maxillary length crown	0.033
" height crown and pedestal	.048
" longitudinal diameter base crown	.02
" transverse	.013
Sixth dentary, longitudinal	.024
" " transverse	.014
Eleventh dentary height crown	.034
" height crown and pedestal	.0505
" longitudinal diameter basis crown	.026
" transverse	.014

The *articular* bone is perhaps .66 the size of that of *Mosasaurus dekayi*

and presents less powerful development of the interior ridge for the pterygoid muscle. The cotylus descends abruptly behind it. The *coronoid* bone exhibits the usual anterior fissure. The rolled front margin of the ascending portion is thickened. The superior surface of the anterior part of the *frontal bone*, is lumpy and with some shallow pits ; the outer face of the articular is smooth. The *vertebra* preserved is a posterior lumbar, and is injured ; the anterior articular face is nearly round. Its vertical diameter is M.058. Length of centrum M.058.

The forms of the teeth distinguish the *Liodon sectorius* from the species of *Mosasaurus*, and that of the vertebra, from such species as *Liodon perlatus*, Cope, and *L. dyspelor*, Cope. There remain to compare with it, *L. proriger*, Cope ; *L. mitchillii*, Dekay ; *L. laevis*, Owen ; *L. congrops*, Cope ; *L. ictericus*, Cope ; and *L. mudgei*, Cope. In size it will only compare with the first two species, being from twice to four times as large as any of the remaining four. The flattened teeth distinguish it at once from *L. ictericus*, and the abrupt rising superior margin of the articular bone, from the *L. mudgei*, where the upper and lower margins are for some distance parallel. The less compressed vertebral centrum distinguishes it from *L. laevis*. From the two large species, dental characters separate it. Thus in *L. proriger* the teeth are less compressed, and are facetted, especially the anterior ones, with concave grooves separated by obtuse ribs. In *M. mitchillii* the teeth present more similarity, but are abundantly distinct. They are much less compressed, even where the posterior cutting edge is strongly developed, the external face is convex to the apex and without concave or flat facet ; it is narrower at the base as compared with the height, and has an incurvature not seen in this *Liodon*. The enamel is smooth, and not striate under the glass.

This and the *L. mitchilli* are the largest Liodons of the Eastern cretaceous. I have recently obtained three anterior dorsal vertebræ and a tooth of the latter, from the lower bed of cretaceous green sand near Freehold, N. J. The vertebræ rival in size those of *Mosasaurus dekayi*, but are of a more elongate form. The articular extremities are cordiform and nearly round, the posterior with the smooth neck band just in front of its margin. In front of this, the surface is sharply striate, especially on the inferior aspect ; the same appears on the bases of the diapophysis. The tooth is like one of those described by Leidy. (Cret. Rept. Pl. XI.)

The *Liodon sectorius* was obtained by Judson C. Gaskill, from the marl pits of the Pemberton Marl Co., at Birmingham, N. J., and liberally placed at my disposal by him.

ADOCIDÆ.

The species of this family display considerable differences in the nature of the sutures of the bones of the plastron. In the thickest species the sutures are fine and the processes very small. This is especially the case with *Adocus pectoralis*. In *A. beatus* which is thinner, the sutures are coarser, but without gomphosis ; that between the hyo- and hyposternal elements looking as though a slight mobility existed in life, as I have

observed in a former article. In *A. syntheticus* the sutures are a little coarser, and in *A. agilis* a further increase is seen, but with but little gomphosis. In *A. pravus*, according to Leidy, there is a little gomphosis, but how much is not ascertainable from his figure and description. In *Homorophus insuetus*, a stouter turtle, the gomphosis is very strong, especially in the longitudinal sutures, where the teeth are long and stout. In *Zygoramma* this coarseness of gomphosis reaches a maximum, being strong in all the sutures of the two species, except the anterior mesosternal of

ZYGORAMMA MICROGLYPHA, Cope, sp. nov.

This large species is represented by the greater part of plastron and half of carapace, with four marginal bones, of an individual from the New Jersey cretaceous, of two and a half feet in length. Its discovery is interesting as enabling me to refer this genus to the *Adocidæ* without doubt, a point which the specimens of the original species, *Z. striatula*, Cope, left uncertain.* The episternal bone displays beautifully the wide intergular scutum separating the lateral reduced gulars. The postabdominal bone displays the swellings corresponding to the pubis and ischium. The pectoral dermal scuta advance medially on the posterior part of the mesosternal bone. These characters are those of *Adocus*. On the other hand there is not satisfactory indication of the intermarginal scuta, though they may exist, and the free marginal bones anterior to the bridge display the double articulation, by suture and gomphosis characteristic of *Zygoramma*. It might be here observed that it is possible that this structure will be found to exist in species at present referred to Adocus, *A. agilis*, for example, where the marginal bones are unknown.

This species is one of those in which the mesosternal is received in the very open emargination of the hyosternals, a character indicating the breadth of the former, and seen in *A. agilis* and *A. syntheticus*. The bones are relatively thin, the marginals light and gently recurved. The anterior lobe of the plastron is truncate, the straight anterior margin grooved lengthwise. The posterior lobe is regularly contracted, and rounded, and with thin edge. The xiphisternal and hyosternal of the right side have each an oblique sutural union with the hyposternal of the left. The mesosternal is broader than long, the posterior margin broadly truncate, the latero-posterior curved sigmoidally, the anterior regularly convex. The episternal is but moderately thickened. The parts of the hyposternals on the bridge are nearly in the plane of the rest of the plastron. The marginal bones near those of the bridge have a thickened shoulder above within, into which the slender costal processes are received: they thin out rapidly and are gently everted distally. More distal marginals are lighter and more everted.

The bones of the carapace include three vertebrals and numerous costals. The latter display very weak capitular processes, but in none are they entirely absent. Neither they nor the vertebrals are thickened. The

* Proceed. Amer. Philos. Soc., 1870, 559.

vertebrals are short coffin-shaped, concave or emarginate in front; a stout laminar neural spine supports the vertebra below.

The sculpture of all the bones is a delicate impressed punctation, the impressions forming lines or delicate grooves in some places. These run obliquely across some of the costals and marginals, and sublongitudinally on the posterior lobe of the plastron. The corneous scuta have left distinct impressions. The marginals extended on to the costal bones at the place of the free marginal bones. The vertebrals were a little longer than wide, with bracket shaped lateral sutures, and openly emarginate below. The intergular plate was pentagonal, with straight sides, and broader than long. The gulars are short and not prolonged very far on the outer margin of the plastron. The pectorals are narrowed laterally, and present a convex median outline on the mesosternum. The abdomino-femoral suture crosses a little behind the middle of the hyposternal bone. The median longitudinal suture winds from side to side on the posterior lobe in the most erratic fashion, abnormally no doubt, and the suture for the anals is anterior, convex in front, sigmoid at the sides.

Measurements.	*M.*
Length of plastron (restored)	0.457
" from front to postabdominal suture	.34
" " to (right) hyposternal	.195
" " to hyosternal	.104
" " to mesosternal	.038
Width at mesosternal	.194
" of "	.095
" at postabdominal suture	.22
Thickness of mesosternal behind	.0116
" of hyposternal medially	.0158
Width of average costal at vert. scute suture	.055
Thickness of same	.011
Total length adjacent vertebral	.066
Greatest width	.036
Width do. at end	.022
Length of first free marginal from bridge	.0655
Width of do.	.10
Thickness proximally	.0175
" of a free marginal proximally	.01
Width " "	.075
Length " "	.0548

The type specimen of this species is about twice the size of that of *Z. striatula*. It also differs in some respects which might be attributed to age, as the greater recurvature of the marginal bones and the greater extent or prolongation of the thickening on the inside of the marginals next the bridge. But there are others which appear to be specific. Thus there is very little evidence of cross-union of sternal elements in the *Z. striatula*, and the sculpture is twice as coarse and so much more marked.

The pegs of the costal gomphosis are absolutely twice as large, and relatively still larger. I therefore believe this specimen to represent another species. Besides the sutural characters, those of the intergular scuta separate this species from *Adocus beatus*. In the latter that scute is urceolate, and the gulars sickle-shaped, being produced backwards on the margins of the episternal or clavicular bones. In *A. syntheticus* the intergular is narrower, and convex behind, the mesosternum is angulate posteriorly, and the plastron much thicker. In *A. agilis* the plastron is nearly similar in thickness, but the mesosternum is angulate behind, and is narrower, and the sculpture very much coarser.

The *Z. microglypha* was found by my friend, Judson Gaskill, in the marl excavations under his direction, at Birmingham, N. J.

AGOMPHUS, Cope.

This name is proposed for a genus of *Testudinata* heretofore not recognized. It appears to belong to the *Emydidæ* so far as known, but to differ from them in lacking the articulation of costal and marginal bones by gomphosis, characteristic of the existing genera of the family. It does not appear to differ in any other point so far as known. The type species is *Agomphus turgidus*, Cope (*Emys* Trans. Amer. Phila,, 1870, 127); others from the cretaceous of New Jersey are *A. firmus*, Leidy (l. c. 126) and *A. petrosus*, Cope, (l. c. 126).

(?) PROPLEURIDÆ, Cope.

Sillim. Amer. Journ. Sci. Arts, 1870, (*L*) 137–8.

Catapleura ponderosa, Cope, spec. nov.

This turtle is represented by two posterior marginal bones, six costals, a hyposternal, scapula and procoracoid, and femur and humerus, all more or less fractured.

The marginals are the caudal, and adjoining one of the right side. They both present a suture for the pygal vertebral, and the lateral presents also a pit for articulation by gomphosis with the last costal bone. They are of heavier form than those of any other species of the group. The hyposternal has had no sutural union with the hyosternal unless exteriorly; this, if existing, has been slight. The shaft of the humerus is contracted and nearly cylindrical; the great trochanter of the femur is little elevated, and not continuous in the plane of the head, but separated from it by a depression.

The above characters express the generic relationships of this type. The gomphosis with the last lateral marginal, as well as the lack of union of the lateral elements of the sternum separates it from Osteopygis; their union is more extensive than in Propleura sopita. This would not prevent the generic unity of the two, were it not for the additional characters of a slender shafted humerus, and probably broad short mandible with long symphysis. In P. sopita the rami are slender, and the sympysis short. The characters are much like those of Catapleura repanda, and I arrange it with that species until better information compels a change.

The *caudal marginal* is strongly concave below, convex above, the margin little recurved. The anterior outline is convex medially, with straight continuations at right angles to each lateral suture. A portion of the edge is broken off. Lateral marginal strongly and openly emarginate, surface not convex as in the median. Both are massive as in Agomphus firmus and allies. The union with the pygal ceases behind the costal pit.

The *costals* are thick and considerably curved transversely to the vertebral axis, the rib heads are unusually large and prominent and subcylindric in section. The rib-ridge is more elevated and rounded in section than in any other species.

The *hyposternal* is from the left side. It exhibits the free articulation for the xiphisternals; the posterior margin is thinned out, while the anterior is more abruptly rounded, and without trace of hyosternal suture. The external face is distally rayed with narrow ridges. The common peduncle of the scapula and procoracoid is short and wide, the sutural face for the coracoid, subtriangular.

The bicipital ridge of the *humerus* is as usual at right angles to the head, and is thin and flat. The plane of the inner crest makes an open angle with the outer; its base is less distant from the shaft than that of the outer. The great trochanter diverges somewhat from the plane of the axis of the head of the *femur*. The latter overhangs the shaft behind; the latter is curved, and beyond the middle subquadrate. In this as in the humerus, one of the two crests is continued as a ridge along the shaft.

Measurements.	*M.*
Length caudal marginal	0.06
Width	.08
Thickness	.0017
Width second ? costal bone	.082
Thickness do. at centre	.013
Width hyposternal at middle	.064
Thickness do. near anterior margin	.012
Length free portion of a rib	.018
Diameter (long) head humerus	.037
" " shaft "	.015
" " head femur	.033
" " shaft "	.016
Width mandible at symphysis at right angles to margin	.034
Thickness mandible at symphysis posteriorly	.011

Accompanying the above remains were those of a small chelydrine turtle, and of a *Taphrosphys*, and a portion of the mandible of a species allied to *Lytoloma augusta* and other species. Its size relates well to the other bones of the *Catapleura ponderosa*, and I suspect that it belongs to that species. It has the expanded form with slightly recurved alveolar margin, of this group; the masseter fossa is strongly marked; the dental

foramen opens almost superiorly; the posterior margin of the jaw is deeply grooved.

The *C. ponderosa* differs from *C. repanda* in its rounded instead of flattened rib-ridges on the inferior surface of the costal bone, and in the different proportions of the crests of the femur. The lesser trochanter in the latter is more robust, and less narrowed and prolonged as a ridge on the shaft. The proximal half of the shaft is straight; in *C. ponderosa* curved.

This species was discovered by John G. Miers, a gentleman who has already enriched palæontology with many interesting forms. From the upper bed of Cretaceous green sand at Hornerstown, New Jersey.

In the nomenclature of the elements of the plastron of the Testudinata, I will in future adopt in part that proposed by Parker (on the shoulder girdle Roy. Society, 1869), who has shown after Rathke that the posterior pieces do not belong to the sternum. The bones from front backwards should then be named, *clavicle* ("episternal"), *mesosternal*, *hyosternal*, *hyposternal*, and *postabdominal* ("xiphisternal").

CROCODILIA.

Bottosaurus macrorhynchus, Harlan.

C. harlani, Meyer. *Bottosaurus harlani*, Agass., Leidy, Cope.

The present state of knowledge of this rare species and genus involve some confusion, and I propose here to set it to rights in a brief manner. This is rendered easy by the discovery of the almost complete skeleton of a nearly grown individual, in the upper bed of cretaceous green sand.

Following my predecessors, I regarded the *Crocodilus basitruncatus* of Owen as this species, in the synopsis Batr. Rept. N. Am., 1869, p. 65, but with expression of considerable doubt. At page 231 of the same work, I distinguished the species of Owen as a true *Holops*. As I had supposed the cervical vertebræ to present the characters of *Holops*, the assignation of the specimens on which this opinion was founded to a species of that genus, left an entire uncertainty as to their character in *Bottosaurus*. The discovery of a series of vertebræ as above mentioned, settles that their structure is not that of the other cretaceous genera, but that of the Tertiary and recent forms, *i. e.*, that the hypapophysis of the cervicals are produced and undivided to the axis. Deducting the erroneously supposed character, there remains one curious feature to distinguish this form from the recent *Alligator*. The fangs of the teeth posterior to the eleventh are not enclosed by the dentary bone, but are exposed to the inner face of the splenial. How far the latter protects them the nature of the specimen does not allow me to decide.

It remains to correct the specific relations of this crocodile. At page 230 of the above work, I described a new species of *Bottosaurus*, under the name of *B. tuberculatus*, establishing it on remains of cranium of one individual and those of the posterior parts of a skeleton of another. The anterior part, with jaws of the latter having fortunately been recovered

as above mentioned, and placed in my hands, I find that the animal belongs to the original *B. macrorhynchus*, and that the first jaw and teeth represent an individual of another species, which will bear the name of *B. tuberculatus*. It differs from the first named in the acute or conic form of the crowns of some of the teeth, and probably in the much smaller size.

In addition to the generic peculiarities already mentioned, this species exhibits a disparity between the lengths of the centra of the lumbar and cervical vertebræ, which is unusual; compare the measurements below with those given for the remainder of the same animal as above cited.

The hypapophysis of the dorsal vertebræ are long, with parallel sides, and oval in section. In that one where the capitular articular face is near the suture of the neural arch, the articular cup is entirely round, and its margin flared out regularly to the capitular surface. The neurapophyses are narrow, and the anterior zygapophyses directed very obliquely downwards.

The *cervicals* are not only shortened, but diminish very much in diameter anteriorly, and the cup continues round. The hypapophysis is very stout on the anterior, more compressed on the posterior vertebræ. The neurapophysial articular faces have the usual rugose anterior and radiate crested posterior areas, but are short and wide, and the anterior area has an oblique concavity extending across it outwards and anteriorly.

The posterior area is, however, the more deeply grooved, especially on the lumbar vertebræ.

The *rami of the mandible* are preserved nearly entire. The large external foramen between the dentary, angular, and articular bones, exists as also the smaller one on the inner face of the ramus. The rami are hollow and thin walled, though of very stout form. The anterior teeth extend along the outer margin of the dentary and then cross to the inner side, the teeth from the twelfth to the eighteenth or last being separated, the first by rudimental septa the latter by mere low ridges. Six of these teeth are exposed without osseous wall on the inner face, and that for the anterior tooth is probably incomplete. The whole length of the ramus is about twenty-eight and a half inches. It is elevated at the position of the tooth usually called the inferior canine; this may be made to appear like an external expansion by rotating the ramus outwards (see Leidy Cretaceous Rept. U. S., Tab. IV. fig. 20). There is another elevation at the seventh tooth behind this point, and a concave curve to the elevation of the articular bone. The angle of the jaw is prominent. The cutting edge is rather obtuse and delicately ridged transversely; the rest of the crown is rugose-striate.

Measurements.	*M.*
Length ramus mandible	0.780
Length series of last seven teeth	.160
Depth ramus at twelfth tooth (from front)	.084
" at external foramen	.145

Measurements.	M.
Length centrum anterior lumbar	.055
Diameter cup do.	.042
" neurapophysis do	.043
" " dorsal	.027
" cup of centrum "	.035
Length base hypapophysis	.03
Length centrum median cervical	.051
Width cup " "	.037
Depth " " "	.035
" " anterior "	.029
Width " " "	.032
" between post. marg. parapophyses	.045
Depth of centrum to lower edge	.04

Bottosaurus macrorhynchus, Harl., was then a crocodilian with a body of the proportions of our alligator, but with larger legs, and relatively considerably larger head. The cranial bones, however, are much less massive, as though to reduce the weight which would prove inconvenient to a body of no larger size. The bones of the mandible are thin and enclose large pneumatic cavities; the teeth are hollow and with thin walls.

I am indebted to Judson C. Gaskill for the opportunity of examining this interesting fossil.

DINOSAURIA.

Hadrosaurus cavatus, Cope, sp. nov.

This species is indicated by remains derived from the upper green sand bed of the upper Cretaceous of New Jersey. They belong to an individual of the gigantic proportions characteristic of the four known species of the genus. It is smaller than *H. tripos* or *H. occidentalis*, and in a less degree smaller than the *H. foulkei*. The remains consist of four caudal vertebræ from the median part of the series, three of them exhibiting rudiments of the diapophyses. In two of them the neural arch remains, one with the spine, and the articular prominences for the chevron bones are nearly complete.

The first character which is observed in these vertebræ is their opistho coelian articulation. The posterior concave face is marked by a more or less prominent elevated band descending from the end of the floor of the neural canal, and which is sometimes grooved medially. The convex extremity is swollen in the middle, most especially so at three points, and a groove or depressed band which has less than one fourth the width of the centrum, extends round the margin outside of it. The general form of the extremities is rounded hexagonal, the anterior a little depressed, the posterior a little compressed. The sides of the centra are quite concave. The chevron articular projections are quite prominent, terminating ante-

riorly in a low ridge which extends to near the anterior face. At the latter position chevron articuar faces are either wanting or very little marked. The centra exhibit no lateral angulation; the third from the anterior has a trace in a longitudinal fulness above the middle of the side; the last, the same, below the middle of the side. The margins of the extremities are well flared. The neural canal is a little compressed and deeply excavated in the centrum. The surface of the centrum is only rugose at the base of the diapophysis. The general form viewed laterally is subquadrate, the anterior vertebra a little deeper than long, the posterior a little longer than deep.

Measurements.	*M.*
Length centrum of anterior	0.66
Depth posterior face	.071
Width "	.084
" of both chevron processes	.05
" of neural canal	.023
Depth neural canal	.023
Length neurapophysis	.04
Third vertebra, depth posteriorly	.071
" depth posteriorly with chevron process	.078
Fourth vertebra, width centrum behind	.075
" depth "	.066
" " with chevron process	.074
Width neural canal	.02
" " spine	.025
" neurapophysis	.034

The measurements of depth of centrum are made from the floor of the neural canal, not from the upper margin of the superior lateral projections of the articular faces.

As in *H. foulkei*, the neural spines have a small antero-posterior diameter, and the zygopophyses are little developed. The anterior are subacuminate and more or less joined together. As the neural spine is very oblique, the posterior zygapophyses are above a point behind the articular extremity of the centrum.

This species differs at once from the *H. tripos*, *H. foulkei* and *H. minor* in the opisthocoelian vertebræ, resembling in this respect the *H. occidentalis* (Thespesius, Leidy). The latter differs from *H. cavatus* in the development of the chevron articulation equally on both adjacent centra, instead of on the posterior extremity only. In *H. foulkei* and *H. tripas* this double junction of chevrons extends to the extremity of the caudal series, adding another important ground of difference between them and the *H. cavatus*. The single caudal vertebra of *H. occidentalis* known, is like that of the former species in this respect, but there is no certainty that the structure continues the same throughout the caudal series, and that the distal vertebræ may not be like those of *H. cavatus* in this re-

spect. It, however, further differs in the relatively more compressed or oval centrum, and much greater size. From *H. minor* the present reptile differs in the opisthocoelian vertebræ, the known caudals of the former having plane articular surfaces, and in the much larger size. It is not possible to compare similar parts of this species and the *Ornithotarsus immanis*, Cope, but the larger size and much lower stratigraphic horizon of the latter renders their identity very doubtful.

Should the genus *Thespesius* of Leidy turn out to be well eatablished, the present species will enter it. I am not, however, entirely satisfied that the difference in the form of the articular faces of the caudal vertebræ is such as indicates generic difference. It was on this ground that I referred this form to *Hadrosaurus* (in Synopsis Extinct Batr. Rept. N. Amer., p. 98), and not from misapprehension of Leidy's definition of it, as the latter supposes (Proceed. Aca. Nat. Sci., 1870, p. 67).

The rather slight material above described is fortunately so characteristic as to enable us to establish satisfactorily the existence of another monster of the remarkable group of the Dinosauria; beings, whose appearance and structure have rivalled the strangest creations of the imagination, and shown again what every other page of the book of nature teaches, that reality is stranger than fiction.

On Two extinct forms of Physostomi of the Neotropical Region.

By E. D. Cope, A. M.

(*Read before the American Philosophical Society, March* 3, 1871.)

Fam. ELOPIDÆ.

Prymnetes, Cope.

Dorsal fin above the anal with short basis and very elongate rays; the posterior ray free and longer than the others. Ventrals posterior. Vertebræ with deep lateral grooves, disproportionally numerous in the abdominal region, viz.: Abd. 49, caudal 18. Tail deeply bifurcated, its exterior or supporting rays, like those of the dorsal, ventral and pectoral, very stout and obliquely segmented. Head short, mouth (in the specimen) inferior; teeth simple, small. Scales with many concentric grooves and a few radii on the proximal portion. No lateral line discoverable.

The pertinence of this genus to the Elopidæ is indicated in various ways. The general form is that of *Elops* and *Megalops*, and the normal and supernumerary ribs are quite as in the former. The interneural spines extending from the head to the dorsal fin, are quite like those of the same genus. It differs from both in the posterior position of dorsal fin, and relatively numerous abdominal vertebræ. From *Elops* it differs especially in the long posterior lash-like ray of the dorsal, and the deeply grooved vertebræ.

Prymnetes longiventer, Cope, sp. nov.

Established on a very fine and nearly perfect specimen, preserved on a

block of lime slate from Chiapas, Mexico. The body is seen in profile, but the head has been pressed from above, and the view is therefore oblique.

The general form is elongate. The pectoral fins are inserted at the pectoral plane, and are of moderate length. The ventrals are short and small. It is uncertain whether they reach the anal, as the anterior part of that fin is destroyed. From the small number of interhæmal spines, the anal has probably had a short basis. Caudal lobes narrow. A strong horizontal interneural spine. The anterior interneurals are like those of *Megalops*, slender, gently curved rods, apparently, but not really continuous with the neural spines in some places. The dorsal fin laid backwards extends to the emargination of the caudal. The vertebræ near the head are not altered. There appears to have been a laminiform crest on the head, but the bones thus described may be those of the opposite side of the cranium. The muzzle appears to be contracted and projecting beyond the mouth. Three narrow obtuse teeth appear on the edge of the premaxillary bone. Dentary bone, stout. Orbit, round, large; entering 4.66 times the head to the posterior margin of the operculum, and 1.33 times the length of the muzzle. Operculum rounded.

Radii; D. 2. 13. 1, C. ?. ?. 6, 6, A. ? V. ? I. 7. P., apparently not numerous, but very numerously divided. There are about twenty-five longitudinal series of scales at a point a short distance anterior to the ventral fins.

	M.
Total length	0.530
Length to orbit	.024
Vertical diameter of orbit	.018
" dentary bone	.016
Length to opercular border	.086
" ventral fins	.310
" dorsal "	.363
" basis caudal	.380
Depth at pectoral fins	.085
" ventral "	.074
" posterior margin dorsal	.04
" basis caudal	.02

This species was found near Tuxtla Chiapas, Mexico, by Dr. J. Berendt, and by him sent to the Smithsonian Institution. Mus. No. 9819–20.

Fam. (?) CHARACINIDÆ.

ANÆDOPOGON, Cope.

Mouth opening almost vertically upwards. Dentition weak, consisting of lancet shaped teeth on the dentary and premaxillary bones; maxillary without or with minute teeth. Post-temporal bone large. Scales with few radii, no concentric grooves or cells.

The pertinence of this genus to the *Characinidæ* cannot be considered as entirely established, as the specimen described does not display any of the fins. The appearance is not unlike that of *Osteoglossum*, but the structure of the scales distinguishes it. The great development of the *sub-* and *postorbital bones*, and small size of the preorbital, distinguish it as allied to the Characins. Its dentition and general form approach the genus *Anacyrtus* Müll. but it is at the same time distinguished by the lack of maxillary teeth. In addition, it appears to lack the anterior interneural spines found in so many Characin and Clupeoid genera, and in families allied to them. They are at least not apparent on the faces of two fractures across the vertebral column. Three *vertebræ* are exposed throughout their length. They are longer than deep, and exhibit the two lateral grooves common to so many Teleosts. The only *scales* preserved are those above the pectoral fins, with but few above the vertebral column. None of these present traces of the lateral line. The *clavicle* makes a right angle with its inferior limb, and with the coracoid, and is produced backwards at the base of the pectoral fin. The *epiclavicle* and *post-temporal* are wide bones. The *operculum* is developed upwards to the epiotic, and the interoperculum is present. A fragment represents the *suboperculum*, which was probaly a narrow bone. The *coracoid* was a broad vertical lamina, extending horizontally forwards to below the preoperculum.

ANÆDOPOGON TENUIDENS, Cope.

Orbit round, its diameter entering the length of the head five times, and a little exceeding that of the muzzle and closed under jaw. The profile is gently descending and perhaps slightly concave; the symphysis mandibuli is very stout and presents an angle outwards; the inferior margin of the dentary is slightly convex. The maxillary bone is slender. The suborbital bones together form a shield deeper than wide; with the postorbitals they reach the preoperculum. The head increases rapidly in depth. The scales are large, and extended below the operculum on the sides of the coracoid region. They have smooth margins, and are everywhere quite thin. The surface is glistening, and in some scales exhibits under the microscope delicate parallel lines which separate short concave lines. The middle of the scale is marked with obtuse tubercular radii, or small or minute tubercles.

Measurements.	*M.*
Length of head	0.14
" of mouth	.061
" of coracoid bone	.091
Depth head at eye	.093
" " vertex	.126
" suborbital bone	.044

Six series of scales between basis of pectoral fin and vertebral column. A mandibular tooth is lancet shaped, and with minutely striate enamel. A premaxillary is more conic; both are rather small.

This species may have more affinities with *Amia* than with the *Characinidæ*. A single specimen was obtained in a clay nodule by the naturalists of the U. S. Paraguay Expedition under Capt. Page, from the neighborhood of Para. It was accompanied by several specimens of a fish from other nodules, which closely resembles an *Aspidorhynchus*. Museum of the Smithsonian Institution.

On the occurrence of fossil Cobitidæ in Idaho.

BY E. D. COPE.

(Read before the American Philosophical Society, March 3, 1871.)

Of the five genera of extinct Cyprinidæ and allied forms discovered by Capt. Clarence King * in the fresh water deposit of Catharine's Creek, etc., Idaho, the writer has been able to indicate the affinities of three. Thus *Semotilus*, *Anchybopsis* and *Mylocyprinus*, were regarded as representations of existing types of both carnivorous and herbivorous habits. *Oligobelus* and *Diastichus* were not assigned to any definite position in relation to known types of the same great group, and I am still compelled to leave the former in the same uncertain position. *Diastichus* I find, on the other hand, presents the peculiar direction of the pharyngeal teeth which is characteristic of the *Cobitidæ*, and I suspect that it represents a form of that family. I am entirely confirmed in this conclusion by the discovery, among the specimens submitted to me by the Smithonian Institution, of the inferior element of the three modified anterior vertebræ, which are so characteristic of certain families of the *Physostomous* fishes. This portion, moreover, is that which occupies this position among the *Cobitidæ* only among them. It consists of a longitudinal plate terminating posteriorly in a bladder-like chamber on each side, each of which is closed below by a transverse process of the inferior plate : an angular fissure extends round the ends of these, and at the angle sends a short continuation upwards. This is quite similar to what is observed in *Cobitis*. The specimen described is apparently adult, and indicates a considerably smaller species than either the *Diastichus macrodon* or *D. parvidens*.

The occurrence of Cobitidæ is perhaps the most interesting fact brought to light by the examination of these extinct fishes. All of the numerous existing species are found in the Eastern Hemisphere, and the great majority in tropical Asia, a few only occurring in Europe and South Africa. Extinct species are found in the Miocene of Oeningen. We have, then, in the genus *Diastichus* another example of the occurrence of Asiatic types in North America prior to the glacial epoch, and as in a freshwater fish, strongly suggestive of continuity of territory of the two continents.

*See Proceed. Amer. Philos. Soc., 1870, 539.

Notes relating to the Physical Geography and Geology of, and the Distribution of Terrestrial Mollusca in certain of the West India Islands.

BY THOMAS BLAND.

(Read before the American Philosophical Society, March 3, 1871.)

In 1861 I published (Ann. Lyc. Nat. Hist., N. Y. VII.) a paper on the Geographical distribution of the genera and species of land shells of the West India Islands, and in 1866 (American Jour. of Conchology, I.) further papers on the same subject. From a study of such distribution, without reference to the Physical Geography or Geology of the Islands, I arrived at the conclusion that they may be divided into the five following provinces or sections, each having a distinct faunal character, viz.:

I. Cuba with the Isle of Pines, Bahamas, and Bermudas.

II. Jamaica.

III. Haiti.

IV. Puerto Rico with Vieque, the Virgin Islands, Sombrero, Anguilla, St. Martin, St. Bartholomew, and St. Croix.

V. The Islands to the south of those last mentioned, to and inclusive of Trinidad.

I remarked that the Islands to the West of Puerto Rico have the greater generic, as well as specific alliance with the North American Continent (Mexico and Central America, of course, included), and those to the East and South, with tropical South America.

Within the last year I have endeavored to learn, if any and what evidence may be gathered from the depth of the sea around, and in the vicinity of the Islands, of their former greater proximity to each other and the adjacent continents, sufficient to account for or throw light on the observed facts of land shell distribution. The result is extremely interesting, and in the main confirmatory of the views above expressed.

The British Admiralty Charts have afforded data, chiefly to the 100 fathom line of soundings only, while recently, through the kindness of Mr. Rawson W. Rawson, Governor in Chief of Barbados and the Windward Islands, I have obtained particulars of the deep sea soundings, taken in the Caribbean sea, especially for Telegraph Cable purposes, by United States and British Naval Officers, which supply information of great value, as I propose in this paper to show. I am also indebted for much information to "The West India Pilot," published by the British Admiralty.

I reserve, for another opportunity, observations on the faunas of the first three of the above mentioned sections, now confining myself to the fourth and fifth, with incidental reference to that of the second. Since the date of my former papers, my knowledge of the species inhabiting the Islands embraced in the latter sections has been largely increased, for which my acknowledgments are due principally to Mr. Robert Swift, of St. Thomas, Dr. Cleve, of the University of Upsala, Governor Rawson, and Mr. R. J. Lechmere Guppy, of Trinidad.

SECTION IV. *Puerto Rico with Vieque, the Virgin Islands, Sombrero, Anguilla, St. Martin, St. Bartholomew, and St. Croix.*

Puerto Rico, Vieque and the Virgin Islands, of which Anegada is the most eastern, stand on one and the same bank, an elevation of which to the extent of somewhat less than 40 fathoms (240 feet) would unite the whole, converting them into one Island. Sombrero is on another bank, about 40 miles from the Virgin bank, and 23 miles from the north end of the Anguilla bank. The depth of the channels which separate the Sombrero bank from the Virgin bank on the west, and the northern end of the Anguilla bank to the east, is not known, but soundings are recorded, at their margins, of 160 fathoms (960 feet) and 190 fathoms (1,140 feet), without bottom.

Anguilla, St. Martin and St. Bartholomew stand on the western edge of another bank of considerable extent. Its southeastern end is 14 miles only from the Antigua bank, and the depth of water between the two is upwards of 122 fathoms (732 feet). An elevation of the Anguilla bank of about 40 fathoms (240 feet) would unite the Islands upon it.

The land shell fauna of the above named Islands is unquestionably the same; it has some alliance with that of Haiti, but very little with that of the Islands to the south of the Anguilla bank. Not only is the absence of certain genera prevailing in Sections I., II., and III. noticeable, but the diminished number of representatives of others is equally so, for example:

	in § I.		§ III.	§ IV.
Megalomastoma	13	species,	1	3
Alcadia	9	"	2	1
Strophia	27	"	2	2
Macroceramus	35	"	10	2
Cylindrella	93	"	28	6

The fact that *Megalomastoma*, *Alcadia*, *Strophia*, and *Macroceramus* are not represented in the Islands south of the Anguilla bank (§ V.) and that in those Islands there are 4 species only of *Cylindrella*, affords striking proof of the difference of their faunas.

St. Croix is not unfrequently classed with the Virgin Islands, from which it is 35 miles distant, but it stands on a bank disconnected from any others and with very deep water around it. Soundings are on record (taken, I believe, by Capt. Parsons, R. N.), between it and the Virgin bank, about the mid-channel, of 1,550 fathoms (9,300 feet), and not far from its northern shore of 2,000 fathoms (12,000 feet), without bottom being found.

The following soundings to the eastward were obtained by the U. S. S. Yantic, in 1870, between St. Thomas and Saba:

		fathoms.	feet.
N. Lat. 18° 01′ 50″.	W. Long. 64° 10′ 20″.	—1,825 —	10,950
" 17° 55′ 00″.	" 63° 50′ 30″.	—1,240 —	7,440

Considering the facts of distribution already given, and the above mentioned soundings, it seems highly probable that very deep water will be found between the Anguilla and Antigua banks.

In this connection it is interesting to notice that the depth of the sea is 1,376 fathoms (8,256 feet) between Cuba and Jamaica, in N. Lat. 18° 36′, W. Long. 76° 03′, a somewhat near approximation to the Latitude of the great depth between the Virgin bank (St. Thomas) and Saba.

The fauna of St. Croix is closely allied to that of Puerto Rico, and seeing the depth of water between them, it is a significant fact that *Caracolla* (*Helix*), *caracolla L.* one of the characteristic species of the latter, is found subfossil only, with other extinct species, and among them a *Strophia*, in the former. *Megalomastoma*, *Alcadia*, and *Macroceramus* do not exist in St. Croix, while there is one species of *Cylindrella*. With further reference to the soundings, the Latitude of Jamaica, and the nature of the fauna of St. Croix, I should mention that *Megalomastoma* and *Strophia* have none, and *Macroceramus* one representative (a Cuban species) in Jamaica, in which Island there are, however, 14 species of *Alcadia* and 51 of *Cylindrella*. Sombrero has one living species (*Chondropoma Julieni* Pf.) which is also found, with a *Strophia*, embedded in the phosphatic limestones of that Island.

Professor Cope lately referred to me, for determination, shells from the matrix between the femoral condyles of *Loxomylus latidens*, Cope, one of the great extinct Rodents, the bones of which have been found in the caves of Anguilla. The shells are closely allied to *Tudora pupaeformis*, Sow, now living on Anguilla, and apparently identical with an undetermined species which inhabits St. Martin.

SECTION V.—*Subdivision* 1. *Islands on the St. Christopher and Antigua banks, Montserrat, Guadeloupe, Dominica, Martinique, and Barbados**.

Subdivision 2. *St. Lucia, St. Vincent, Grenada and the Grenadines, Tobago, and Trinidad.*

In former papers I did not treat the fauna of the Islands in this section as capable of subdivision, but with my present increased knowledge must necessarily do so.

Immediately to the south of the Anguilla bank there is, to the eastward, a bank on which stand Barbuda and Antigua, and to the westward, another (separated from the adjacent Islands by channels of a greater depth than 200 fathoms, 1,200 feet), which constitutes the base of St. Eustatius, St. Christopher, and Nevis. At a short distance from the northern end of the latter bank stands Saba (about 2½ miles in diameter,) rising perpendicularly from the sea to the height of 2,820 feet, with the 100 fathoms (600 feet) line of soundings about half a mile from its western, and a little more than half that distance from its eastern side. Late soundings between St. Eustatius and Saba (Lat. 17° 31′ 10″, Long. 63° 08′ 30″) give a depth of 343 fathoms (2,058 feet).

* I omit mention of several small Islands geographically belonging to those enumerated in both subdivisions.

Within 3 miles S. W. from Saba is the Saba bank, which forms nearly a parallelogram, its longest sides about 32 miles and its shortest about 20 miles in extent, the eastern edge fringed with a narrow ledge of living coral, sand and rock, nearly 30 miles in length and varying in depth from 6½ to 10 fathoms.

It is remarkable that an elevation similar to that mentioned with reference to the Virgin and Anguilla banks (less than 40 fathoms,) would unite Barbuda and Antigua, also St. Eustatius, St. Christopher and Nevis, and convert the Saba bank into an Island.

With respect to Guadeloupe, Dominica, Martinique, &c., the following particulars of soundings lately taken by the U. S. S. "Yantic," Commander Irwin, are extremely interesting :

Between			fathoms.	feet.
Antigua and Guadeloupe,	Lat. 16° 40′.	Long. 61° 48′.	348	— 2,088
Guadeloupe and Dominica,	" 15° 45′.	" 61° 37′.	850	— 2,700
Dominica and Martinique,	" 15° 06′.	" 61° 20′.	1,078	— 6,468
Martinque and St. Lucia,	" 14° 17′.	" 61° 04′.	1,232	— 7,392
St. Lucia and St. Vincent,	" 13° 33′.	" 61° 20′.	1,346	— 8,076

Capt. Parsons, R. N., found on a line of soundings from St. Vincent to Barbados, depths of 350, 956, 1,218 in (about) Lat. 13° 05′, Long. 60° 25′, 1,211, and 147 fathoms, the greatest ascertained depth being equal to 7,308 feet.

The same officer obtained the following results from soundings between Barbados and Tobago, viz. :

		fathoms.	feet.
N. Lat. 13° 00′.	W. Long. 59° 40′.	300	— 1,800
" 12° 40′.	" "	570	— 3,420
" 12° 30′.	" 59° 50′.	780	— 4,680
" 12° 10′.	" 60° 05′.	1,030	— 6,180
" 11° 40′.	" 60° 10′.	1,060	— 6,360
" 11° 27′.	" 60° 25′.	500	— 3,000 without bottom.

I have already given the depths between Martinique and St. Lucia, that Island and St. Vincent and the latter and Barbados. St. Vincent is separated from the northern end of the Grenada bank, on which Grenada and the Grenadines are situated, by a narrow channel, not over, Capt. Parsons remarks, 300 fathoms (1,800 feet) deep. The Grenadines consist of a chain of Islands and rocks extending for 60 miles between Grenada and St. Vincent. The depth found on soundings taken by the "Yantic," gave on and near to the west side of St. Vincent, in about the Latitude of its northern end, 1,080 fathoms (6480 feet), opposite the channel to the south of St. Vincent 594 fathoms (3,564 feet), and along the West side, in close proximity to the Grenada bank, from North to South, 880 fathoms (5,280 feet), 801 fathoms (4,806 feet), 916 fathoms (5,496 feet), and 545 fathoms (3,270 feet).

Trinidad and Tobago are on soundings (less than 100 fathoms), both being in fact on the submarine slope of the South American Continent, and the deeper water found by the "Yantic" between the former Island and the Grenada bank, in (about) Lat. 11° 50′, Long. 61° 45′, was 386

fathoms (2,316 feet), while the maximum depth known, as above stated, between Tobago and Barbados, is 1,060 fathoms (6,360 feet).

It appears from the foregoing evidence, that Trinidad, Tobago, the Grenada bank (an elevation of which to the extent of 40 fathoms would give an Island nearly 100 miles in length), and St. Vincent, stand on a partially submerged ridge, an extension of the South American Continent, having, say, 1,000 fathoms depth of water on the west side, and still greater depths between its northern termination and St. Lucia, also on its eastern side between it and Barbados, and between the latter Island and Tobago. The summit of this ridge is 2,316 feet beneath the level of the sea between Trinidad and the Grenada bank, and, say, 1,800 feet between that and St. Vincent, while the altitudes above the sea are, of Trinidad 3,100, Tobago 1,800, Grenada 2,746, and St. Vincent about 3,000 feet.

The genera and species of land Mollusks which occur in the Islands on the "submerged ridge" just mentioned (Trinidad to St. Lucia inclusive), are chiefly allied to those which are characteristic of Venezuela, the portion of the Continent contiguous to Trinidad. The species of *Helix*, in its wide application, including *Stenopus*, *Hyalina*, and *Zonites*, are 15 only in number, while there are of *Bulimus* (as restricted by Albers) 5, and of *Bulimulus* 14 species, the total number of species of the latter in the West Indies, being about 38. The subgenus *Dentellaria* (*Helix*) is characteristic of the Islands embraced in Subdivision 1 of Section V., but has few representatives in those named in Subdivision 2. *D. perplexa*, Fer., is peculiar to the Grenadines and Grenada, *D. Isabella*, Fer., is common to one of the Grenadines, Barbados, and Cayenne, (French Guiana,) and *D. orbiculata*, Fer., to St. Lucia, Martinique and Cayenne.

The genus *Bulimus*, of which the subgenera represented are *Borus*, *Pelecychilus*, and *Eurytus*, all South American, occurs in the West Indies only in the group (subdivision 2) embracing St. Lucia and Trinidad and the intermediate Islands. *Borus oblongus* inhabits Barbados, but it was introduced there from St. Vincent by the late Rev. Mr. Parkinson. *Eurytus aulacostylus*, Pf., occurs both in St. Lucia and Demerara. With respect to Trinidad, it is certainly curious that we have there a species of *Diplommatina* (*D. Huttoni*, Pf.) and of *Ennea* (*E. bicolor*, Hutton). the latter found also in Grenada and St. Thomas, both living in the East Indies. Guppy has lately discovered a species to which he has given the generic name of *Blandiella*, but it is, I think, a *Truncatella*, allied, at least, to the subgenus *Taheitia*, H. and A. Adams, the type of which is *T. porrecta*, Gould, of Taheiti.

The land shell fauna of the Islands in subdivision 2 have marked alliance with that of Cayenne. There are on that group six species of Helix which are also found in Cayenne, viz.: *Dentellaria orbiculata*, *nux-denticulata*, *dentiens*, *Isabella*, *badia*, and *Thelidomus discolor*. The genus *Cyclophorus* has no less than seven species in Martinique, Dominica, and Guadeloupe, but none in any other part of the West Indies, while one, a different species, inhabits Cayenne. In Barbados no member of the family Cyclostomacea has been discovered. I have already referred to some other peculiarities of this fauna as compared with that of the Islands

embraced in section IV, and should add that Dentellaria *does not* occur in those Islands. *Helix* predominates over *Bulimus* in North America and the Islands in Sections I., II., III., and IV, while the reverse is the case in South America, and there is at least an increased proportionate number of *Bulimus*, as compared with *Helix* in Section V.

I have spoken of a "ridge" on which the Islands in subdivision 2 of that section stand (St. Lucia excepted), and must remark in addition, that there may have existed an extension of the South American Continent, from the eastern boundary of Guiana to some point west of the Grenada bank, and running North to the neighborhood of the Anguilla bank, on the western side of which extension there was the fauna now to be studied in the Islands from St. Lucia to Trinidad, and on the eastern side, in those from the St. Christopher and Antigua banks to Barbados.

Reference has been made to the similarity of depths in nearly the same Latitude between Jamaica and Cuba, and Saba and the Virgin bank.

Mr. Rawson has directed my attention to a comparison of the following depths in the Caribbean sea, ascertained by soundings between Kingston (Jamaica*) and Chagres, and those between Barbados and Tobago :

Lat. 12° 00′.	Long.	79° 25′—924 fa.	Lat. 12° 10′,	Long.	60° 05′—1,030 fa.
" 11° 25′,	"	79° 30′—969 fa.	" 11° 40′,	"	60° 10′—1,060 fa.

Taking a wide view of land shell distribution in the West Indies, it may be said that the fauna of the Islands on the northern side of the Caribbean sea, from Cuba to the Virgin and Anguilla banks, was derived from Mexico and Central America, and that of the Islands of the eastern side, from the Antigua and St. Christopher banks to Trinidad, from tropical South America. It is noticeable that the mountains in the former Islands, range, generally, from West to East, but in the latter from South to North, excepting in Tobago and Trinidad, where they are parallel with, or in the same direction as the coast mountains of the adjacent continent.

The present geological condition of the Islands affords ample evidence of the lapse of vast periods of time in the earlier tertiary epochs, during which the Limestone formations, extensively developed in most of the Islands, were deposited. The white Limestone of Jamaica, referred by Sawkins (Geology of Jamaica, London, 1869), to the Post Pliocene, covers more than three-fourths of the Island and is computed at 2000 feet in thickness. It rests on the yellow Limestone (Miocene), which, he remarks, during the deposition of the former, "sank to great depths, in some places apparently 3000 feet, so as to permit the growth of those great coral structures, from the débris of which the enormous calcareous development of the white Limestone has been derived. The lapse of time required for these important phenomena cannot be easily realized by the imagination."

That the Islands, or some of them, were formerly united and formed part of an ancient continent, may, it would seem for various reasons, be inferred, and the discovery of mammalian and other remains in Anguilla, Sombrero, etc., is an important one.

* The Pedro bank, within 50 miles of the southern shores of Jamaica, with an elevation of 30 to 60 fathoms would give an Island 100 miles long, 30 in breadth near its centre, and 45 at its western edge.

Referring to the Anguilla cave remains, Prof. Cope remarks (Proc. Acad. N. S. Phila., 1868) on their indicating "that the Caribbean continent had not been submerged prior to the close of the Post-pliocene, and that its connection was with the other Antilles, while a wide strait separated it from the then comparatively remote shores of North America."

The occurrence with the Anguilla fossils of a land shell of a species now living, points to the age of the existing tauna, but the marked difference, both generic and specific, between the present land shell fauna of the Islands upon and to the North and West of the Anguilla bank and those to the South of it, may be taken as evidence of their early and continued separation.

Captain Parsons, in MS. Notes on the Geology of some of the West Indies, for a perusal of which I am indebted to Mr. Rawson, observes that the eastern or windward edge of the Grenada bank is at an average distance of 7 miles from the Islands, while the western edge is not more than two-thirds of a mile, and that there is a similar great disparity in other of the banks and Islands. He concludes that such increased development of the eastern over the western sides is primarily due to the equatorial current, which running for ages through the Islands has brought and deposited material on the windward side.*

On this subject, the following quotation from "The Natural History of Barbadoes," by the Rev. W. Hughes, London, 1750, is really interesting, and particularly so in connection with the views of Sawkins with regard to Jamaica.

"The current of the Deluge between the Tropics ran from East to West. Notice the shattered condition of the eastward side of the chain of hills and cliffs, which are as barriers to the Island (Barbados), from Cuckold's Point to Conset's Bay, for as they face the East their torn state on that side alone and no where else, shews that they not only by their situation, first stemmed, but as they were higher than any other part of the Island, they wholly bore the repeated percussions of the current in the gradual ascent of the Deluge. Notice, also, the coping figure of the Island from East to West, for if we view narrowly the several gradual descents of so many continued ridges of rock, like cascades, descending precipitously to the westward (for instance, the long chain of hills from Mount Gilboa, in St. Lucia's Parish, to the Black Rock in St. Michael's), we shall conclude from the deep soil on the eastward of these where the land is level, and from the rugged and bare washed surface of the west, that the latter was thus torn by the violence of the waters falling over them, and the former, the effect of the subsided sediment upon the decrease of the Deluge. The want of such a bed of rocks from Black Rock to St. Anne's Castle caused the chasm which opens to the sea through Bridgetown opposite to the Valley of St. George's. The course of the guilies is, too, from East to West, and they were caused by the current of the Deluge, the regular course of which to the westward between the tropics was the natural consequence of the easterly trade wind."

* In the Bahamas the Islands are, generally speaking, on the windward side of their respective groups and banks.—(*Nelson.*)

Sawkins, in the Report on Jamaica, to which I have already referred, shows that the highest elevations on that Island are situated to the east, and the inclined slope rises from the west. With respect to this, he draws "deductions from two important elements:

"1. The great equatorial currents have existed in times past as at present.

"2. That the trade winds also prevailed with the same uniformity."

Referring to vestiges of volcanic action and certain stratified deposits towards the eastern end of the Island, containing pebbles and debris of previously existing rocks, Sawkins remarks: "This (volcanic) action might have operated intermittently, so as to permit the growth of coral reefs, marine animals, &c., of which the remains are contained in the limestone formations. Again, supposing the deposits to have originated from local igneous or volcanic action, or from debris derived from islands to the east, submersion having intervened, the lighter materials and finer sediment would be transported by the currents to the westward, these influences combining with subsequent changes of level, account for the prolongation of the land to the westward."

In connection with the facts stated I can only incidentally refer to the barrier presented by Trinidad, Tobago, the Grenada bank, and St. Vincent to the distribution, to the westward, of marine forms living at greater depths than 400 fathoms; and to the same barrier and others offered by the Islands and banks to the North of St. Vincent, to the flow of the equatorial current into the Caribbean sea. Also to the existence of a cold current at great depths between Barbados and Tobago, shown by the temperatures ascertained by Capt. Parsons, viz.:

Surface, Max.	79° Fah.,	at 1,030	fathoms,	Min.	38°
"	82° "	" 1,060	"	"	38°.5

Stated Meeting, March 17, 1871.

Present, seventeen members.

Dr. Wood, President, in the chair.

Photographs of Mr. Frederick Graff and Prof. D. F. Sandberger, of Würzburg, were received for the Album.

A letter of envoy was received from the Swedish Bureau of Statistics.

Letters of acknowledgment were received from Herr Haidinger, of Vienna (for Proc. No. 81, 82); Dr. D. F. Sandberger (81, 82, 83); Edinbourg Observatory (82); Prof. Bunsen (82, 83); Prof. Kirchhoff (82, 83); Smithsonian Institute and Essex Institute (85); Harrisburg State Library and Baltimore Peabody Institute (Proc. 85 and Trans. XIV.-III.); D. H. Storer, Yale College (85, XIV.-I.); West Point Academy Library

(85, XIV.–III.); N. Y. N. H. Lyceum, New York, New Jersey, and Massachusetts Historical Societies, Boston Public Library, and American Antiquarian Society (all for Trans. XIV.–I.).

An extract from a letter of Mr. Carlier to Mr. Durand, respecting the Michaux Legacy, was read.

Donations for the Library were received from the R. Prussian Academy, the Society at Leyden (Flora Batava), the Statistical Bureau of Sweden, the Museum of Com. Zool. of Harvard College, Prof. Mayer of S. Bethlehem, the College of Pharmacy, Medical News and Penn. Monthly, of Philadelphia, Mrs. M. E. Tyson, of Baltimore, the State Geologist of Illinois, the Minnesota Historical Society, and Mr. W. H. Jackson.

The death of Judge Conyngham, of Wilksbarre, Pa., a member of the Society, was announced by the Secretary, and on motion of Prof. Cresson, the Rev. Bishop Stevens was appointed to prepare an obituary notice of the deceased.

The death of Prof. Charles M. Wetherill, of Lehigh University, Pa., was announced by the Secretary, and on motion of Prof. Cresson, Prof. Frazer was appointed to prepare an obituary notice of the deceased.

Prof. Cope exhibited a suite of fossils obtained by further exploration of the Bone Cavern near Port Kennedy, and informed the members of the progress of the examination. A discussion ensued, in which Prof. Cope expressed his views of migration, considering that the higher types belonging to Eocene and Miocene ages (including the fresh water fishes, Idaho), being all Asiatic, show a land emigration over the space now occupied by the North Pacific Ocean. When this fauna was destroyed by cold, the sinking of the North Pacific area, and the ice barrier together prevented its restoration. It was, therefore, replaced by a fauna of a lower type from Central America.

Mr. Chase communicated his views of the anticyclonic character of our winds and periodic storms between the 25° and 46° N. Lat. parallels, and between the meridians of Passamaquoddy and 100° West.

Pending nominations Nos. 669, 670, and new nominations Nos. 671, 672, 673, 674, were read.

And the meeting was adjourned.

Winds of the *United States.*

By Pliny Earle Chase.

(Read before the American Philosophical Society, March 17, 1871.)

Notwithstanding Ferrel's mathematical, and Galton's practical, demonstration of the tendency, in winds of propulsion, to become anti-cyclonic, many meteorologists regard cyclonic atmospheric currents as normal, in fair as well as in stormy weather. Such an impression may be naturally strengthened by the admitted facts, that most of the European winds are cyclonic, that all currents flowing in towards a centre of low pressure, speedily become cyclonic, and that the system of aspiration induced by the diminished pressure at the equator, is the proximate cause of all our atmospheric circulation.

But it should be remembered on the other hand, that the normal motion of the principal oceanic, atmospheric and magnetic currents, both polar and equatorial, and the daily veering of the wind consequent on the progressive heating of the earth's surface, are confessedly anti-cyclonic; that centres of violent and rapid commotion must necessarily cover a smaller area than the less disturbed peripheries which help to restore the equilibrium; that the air drifts more often in alternate ridges and troughs than in spirals; and that downward pressure is the impelling force by which the partial vacua, produced by increase of temperature or by condensation of vapor, are supplied. Each of these considerations is indicative of systems of winds over the entire globe, which are normally anti-cyclonic, and only exceptionally cyclonic. Even in storms, the blending of opposite currents may take place at a circumference as well as at a centre, and condensation of vapor may be going on along an extended line, the equilibrium being restored by the pressure of an adjacent ridge, as well as over a limited area towards which there is an influx from all quarters. There may, therefore, be anti-cyclonic as well as cyclonic storms. In fact, as I stated at the last meeting of the Society, most of our recent storms have been of the former character, and the more closely I have scrutinized the Signal Service observations, the more strongly have I been impressed with the belief that most, if not all, of our north-easterly storms are anti-cyclonic as a whole, though they may be accompanied by limited and comparatively insignificant local cyclones, and although, in consequence of the trend of our Atlantic coast and the in-draught towards the gulf stream, they may assume a form more or less cyclonic as they leave our shores.

The charts in Coffin's Winds of the Northern Hemisphere, seem to me to furnish ample confirmation to these views, although, in consequence of their very admirable fulness of detail, general tendencies are sometimes disguised by the local deflecting influences of mountains, lakes and valleys. In order to eliminate such local disturbances, I have grouped by States and Territories, all the winds in the first volume of the "Results of Meteorological Observations," from 1854 to 1859 inclusive, and computed the resultant for the entire period for each district.

I. Number of Winds from each cardinal point.

	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.
British America	1651	3599	853	2645	2098	4735	3055	4932
Maine	2008	4331	1198	2664	2248	6349	3324	8342
New Hampshire	860	1464	1234	1607	933	2652	3057	4641
Vermont	3585	761	401	1150	6225	2018	1976	4040
Massachusetts	3681	7158	2619	6068	3802	13656	8020	18095
Rhode Island	133	518	73	120	241	720	199	1114
Connecticut	1560	2636	675	1569	1842	4352	1498	5940
New York	4639	6581	3692	6582	8676	14314	14882	13342
New Jersey	1016	2599	658	1423	1056	4158	2377	3989
Pennsylvania	4556	6399	6743	6848	6398	13617	17346	16930
Delaware	39	147	59	90	42	164	97	316
Maryland & D. of C	1650	2849	1082	1674	2621	3812	4410	3870
Virginia	3725	3230	1759	1790	4590	5616	3400	4319
North Carolina	1019	1760	470	512	809	2019	2080	1122
South Carolina	1248	3252	1036	2026	1505	3989	1616	2306
Georgia	1585	3436	2052	2595	2415	3240	2611	4118
Florida	2374	6455	2651	3831	1411	4265	1801	3141
Alabama	676	508	548	1307	734	859	897	1096
Mississippi	923	929	738	1211	971	1253	812	1447
Louisiana	736	969	194	1040	793	782	134	659
Texas	4357	1011	1168	2966	5871	1510	1009	1181
Tennessee	567	649	316	884	980	755	393	715
Kentucky	604	1343	447	762	1218	3159	1453	1650
Ohio	3151	5277	1976	6509	4742	14747	7449	9828
Michigan	2079	3508	2776	3427	3061	7300	6170	5608
Indiana	1449	1086	990	1853	1910	2901	2591	2418
Illinois	3510	7151	3593	6963	8026	11218	8063	9126
Missouri	531	492	678	1195	906	838	1081	710
Wisconsin	3321	4932	2689	4073	4150	6967	5374	5906
Iowa	2249	3144	1636	5370	3648	5891	3063	7374
Minnesota	915	753	910	782	1469	710	1209	2033
Nebraska	1035	436	235	598	1226	434	287	717
Kansas	984	491	360	757	1371	559	182	586
Mexico	172	345	73	59	68	144	85	123
California	985	235	185	904	1272	1175	979	904
Bahamas	163	348	252	292	217	418	200	182
Guatemala	56	806	18	16	3	262	6	52
Surinam	89	803	417	427	141	39	5	19

II. Percentages, and Resultant Winds.

	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Resultant.
British America	7	15	4	11	9	20	13	21	N. 85°28' W.
Maine	7	14	4	9	7	21	11	27	" 72 47 "
New Hampshire	5	9	7	10	6	16	19	28	" 75 39 "
Vermont	17	4	2	6	31	10	10	20	S. 71 46 "
Massachusetts	6	11	4	9	6	22	13	29	N. 78 26 "
Rhode Island	4	17	2	4	8	23	6	36	" 65 4 "
Connecticut	8	13	3	8	9	22	7	30	" 72 43 "
New York	6	9	5	9	12	20	21	18	S. 77 34 "
New Jersey	6	15	4	8	6	24	14	23	N. 81 45 "
Pennsylvania	6	8	9	9	8	17	22	21	" 89 20 "
Delaware	4	16	6	9	5	17	10	33	" 55 23 "
Maryland & D. of C	7	13	5	8	12	17	20	18	S. 88 59 "
Virginia	13	12	6	6	16	20	12	15	" 81 31 "
North Carolina	10	18	5	5	8	21	21	12	N. 78 22 "
South Carolina	7	19	6	12	9	23	10	14	S. 65 57 "
Georgia	7	15	9	12	11	15	12	19	N. 74 59 "

Florida	9	25	10	15	5	16	7	13	N 50 7 E.
Alabama	10	8	8	20	11	13	14	16	S. 44 25 W
Mississippi	11	11	9	15	12	15	10	17	" 76 48 "
Louisiana	14	18	4	20	15	15	2	12	" 67 10 E.
Texas	23	5	6	16	31	8	5	6	" 13 28 "
Tennessee	11	12	6	17	19	14	7	14	" 8 57 W.
Kentucky	6	13	4	7	11	30	14	15	" 67 53 "
Ohio	6	10	4	12	9	27	14	18	" 67 45 "
Michigan	6	10	8	10	9	22	18	17	" 74 26 "
Indiana	9	7	7	12	13	19	17	16	" 67 40 "
Illinois	6	12	6	12	14	20	14	16	" 52 18 "
Missouri	8	8	10	19	14	13	17	11	" 17 34 "
Wisconsin	9	13	7	11	11	19	14	16	" 79 50 "
Iowa	7	10	5	17	11	18	9	23	" 68 6 "
Minnesota	10	9	10	9	17	8	14	23	N. 82 39 "
Nebraska	21	9	5	12	25	8	6	14	S. 50 4 "
Kansas	19	9	7	14	26	11	3	11	" 24 18 E.
Mexico	16	32	7	6	6	13	8	12	N. 16 15 "
California	15	3	3	14	19	18	15	13	S. 56 53 W.
Bahamas	8	17	12	14	10	20	10	9	" 23 53 E.
Guatemala	5	66	2	1	0	21	1	4	N. 43 17 "
Surinam	5	41	22	22	7	2	0	1	" 80 53 "

This grouping, by exhibiting the excess or deficiency, in the percentage of any given wind, from the percentage of the same wind in adjacent districts, shows local irregularities which are often easily explicable by the physical features of the neighborhood, and enables us, by plotting the general resultants on a map, to demonstrate the anti-cyclonic motion of the air, over the entire region between the twenty-fifth and forty-fifth parallel of latitude, and between Passamaquoddy Bay on the east, and the 100th meridian on the west. It shows, moreover, that there is a normal intersection of a polar (N. E.) current off the coast of Florida, with an equatorial (S. W.) current from the Bahama Islands, and a similar intersection of a south-easterly and south-westerly equatorial current, (the latter having been refrigerated by the Sierra Nevada,) near the common boundary line of Nebraska and Kansas. The former of these intersections is analogous to the one referred to by Mr. Scott, as indicative of an approaching gale in the British Islands, and suggests an obvious explanation of the gulf stream cyclones, as well as of the cyclonic winds in Western Europe; the latter helps to account for a considerable proportion of our land storms.

The comparison of these currents and intersections with Blodget's hyetal charts is very instructive, and I feel little hesitation in predicting that a more thorough acquaintance with the winds of Alaska and British America, will develop another anti-cyclonic system, referable to a different centre of disturbance, with intersecting normals near the northern boundary line between the polar and equatorial prevailing winds, and perhaps in the valley of the Saskatchewan, which has been specially designated by Professor Henry as a storm-breeding district.

Resemblance of *Atmospheric, Magnetic and Oceanic Currents.*

By Pliny Earle Chase.

(*Read before the American Philosophical Society, April* 7, 1871.)

My belief that terrestial magnetism is dependent solely upon fluid currents, electrified by convection and by the condensation of vapor, led me to look for some confirmation of my views in the results of my recent discussions of the winds of the United States. My attention was first drawn to the resemblance between the looped isogonic lines in the eastern equatorial portion of the Pacific Ocean, and the anti-cyclonic course of the winds in the Gulf States. The undoubted rapidity of magnetic action, a rapidity analogous to, if not identical with, that of luminiferous vibrations, renders it probable that the flexure of the isogonic lines, at any given point, may be determined by the resultant of all the forces acting at that point, and that the equatorial loops are, therefore, expressions of equatorial disturbance.

If the same disturbance is communicated to the more sluggish air, its culmination may naturally be sought at some point northward and eastward, because of the well-known laws of current deflection. The principal thermal contrasts which contribute to the establishment of currents, are: 1st, land and water; 2d, polar and equatorial; 3d, heat and cold at isabnormal centres. It seems reasonable to suppose that these triple contrasts should be so mutually related, that there may be some system of rectangular coördinate planes which would present each of them as a maximum.

A great circle cutting the equator on the meridians of 100° W. and 80° E., and passing through the geographic centre of the land hemisphere, follows the general trend of the American coast from Florida to Newfoundland, skirts the equatorial isogonic and the Florida atmospheric loops, finds the western limit of our anti-cyclonic system of winds at a point about midway between the magnetic pole and the equator, and crosses the equator on the meridians and near the centres of greatest Horizontal Force. A co-ordinate great circle following the meridians of 10° W. and 170° E., intersects the magnetic equator of minimum intensity near its greatest northern and southern elongations. The third co-ordinate great circle corresponds very nearly with the dividing plane between the land and water hemispheres. The principal north pole of declination and the Asiatic equatorial intersection of the line of no variation, are on the meridians first named, which traverse the intersections of the first and third co-ordinate circles. A great circle intersecting the second co-ordinate on the equator, and passing near the North American pole of declination, would cut the first of these meridians (100° W.) at an angular distance from the pole analogous to that of the Florida wind loop from the equator, traversing the principal isogonic loops in such manner as to exhibit the magnetic symmetry of the entire globe to the best advantage. No other system of rectangular co-ordinate planes would meet with so little land interruption, or would divide the globe into hemispheres with so great current-producing contrasts.

An observer, therefore, near the centre of the land hemisphere, would find, at the four cardinal points of his true horizon, magnetic, thermal and geographic positions of peculiar importance, and indicative of interesting mutual relations. The recognition of such relations gives a new interest to the often noticed resemblance between the isoclinal and isothermal lines, the analogy which I have myself pointed out between the isogonic and cotidal lines, the parallelism of the boundary lines and of the axis of the westerly isogonic belt with the boundaries of the corresponding annual isabnormal belt, the isogonic curvatures in or about regions of isabnormal heat or cold, the different angular relations of the isogonic lines to the customary paths of hurricanes and storms, and the approximate perpendicularity of direction and opposition of curvature between the westerly wind belt and the isogons. All of these features, which may be satisfactorily explained by the general principles on which storm laws are based, furnish cumulative, if not irresistible, evidence of the dependence of magnetic currents upon the same laws of gravitation, which tend to restore the equilibrium of air and sea, after tidal or thermal disturbances. The evidence is sustained not only in the general distribution of the magnetic lines, but also in their particular details, the course of the isogonic lines, *at every point*, being an evident resultant of the combined equilibrating tendencies between land and water, and between centres of normal and isabnormal heat and cold.

The ocean currents corroborate the gravitation theory of magnetism, perhaps even more strongly than the wind belt. A physical atlas like Petermann's, which marks the most rapid portions of the several currents with the deepest tints, shows their relation to the magnetic and coast lines very satisfactorily. A comparison of the more minute details exhibits additional interesting evidence that the original impulse of all terrestial currents, atmospheric, magnetic and oceanic, is given by luminous, thermal or tidal disturbances, that the currents are maintained by gravity in its continual tendencies to restore the continually disturbed equilibrium, that the magnetic currents are least, while the ocean currents are most interrupted and modified by land contours, that each of the more sluggish currents exerts a secondary modifying influence on the more rapid, that extraordinary variations in thermal or luminous undulations, whether originating at the sun or at the earth, produce "magnetic storms," and that, whatever theory may be adopted as to the mode in which the solar undulations are transmitted, there is no philosophical necessity for the hypothesis of any cosmical origin or disturbance of terrestrial magnetism other than variations in the amount of light and heat received and in the directions of gravitating tidal and equilibrating lines.*

* It is so difficult to make the necessary allowances for the distortions of the ordinary magnetic charts, that I would recommend any one, who may desire to make the comparisons which I have suggested, to trace the lines on a globe. A slate globe is especially satisfactory. The data for my own comparisons were taken from the lines of equal magnetic variation and of equal horizontal force for 1860, in the 2d edition of the "Admiralty Manual for ascertaining and applying the deviations of a compass, caused by the iron in a ship." Walker's "Terrestial and Cosmical Magnetism;" Coffin's "Winds of the Northern Hemisphere;" Dove's "Isothermal and Isabnormal charts," "Petermann's and Johnston's Physical Atlases." In order to judge of the resultant influences of the normal and isabnormal thermal disturbances, it will be well to mark the *centres* of isabnormal heat and cold, as well as the points of greatest average heat and cold.

Mr. Walker, in his Adams Prize Essay for 1865, p. 268, says: "it is worthy of remark that the portion of the year when the magnetic force is the greatest, and the direction of the needle most vertical in *both* hemispheres, coincides with that at which the earth is nearest to the sun and moves with the greatest velocity in its orbit. This fact furnishes another argument against the theory that these effects are due to *temperature*, as in that case they ought to occur at *opposite* periods of the year in the two hemispheres, whereas in fact they occur at the same period in both." The writer was doubtless misled by the annual variations in declination and horizontal force, which are evidently dependent upon the relative temperature of the northern and southern hemispheres. But if all the magnetic effects are primarily due to thermal and gravitating motion, it is evident that the *total* magnetic force must depend upon the *total* current producing energy of the sun, which is, of course, a maximum when "the earth is nearest the sun, and moves with the greatest velocity in its orbit." The argument which was considered conclusive against the theory, is, therefore, wholly in its favor.

THE CAUSES OF *Regional Elevations and Subsidences*, by LIEUT. C. E. DUTTON.

(*Read before the American Philosophical Society, April* 7, 1871.)

Lieut. C. E. Dutton, desired to submit certain views, which he had been led to entertain, respecting the causes of regional elevations and subsidences. He was unacquainted with any views on this subject in the writings of geologists, which seemed to be satisfactory. In reflecting upon the nature of metamorphic rocks, and the probable changes which they had undergone, he thought that the facts brought to light by the researches of Bischoff, Daubrée, Sorby, Sterry-Hunt and others in that field, might contain, also, a solution of the unexplained problem of elevations and subsidences. It is now a generally accepted opinion among writers upon chemical geology, that metamorphic rocks have reached their present condition, through the combined agencies of heat, pressure, and water, acting upon sedimentary strata; that sulphur, carbonic acid and volatile chlorides and fluorides have played highly important parts under similar conditions, and that soluble earths and metallic salts and vapors have had no inconsiderable influence upon the totality of changes. That water especially, under the influence of a moderately high temperature and great pressure, is capable of changing in a wonderful manner the structure and arrangement of rocky materials of all kinds, has been abundantly shown by innumerable synthetical experiments, a great number of which have been summed up by Daubrée in an able memoir on the subject to the French Academy. He has also shown that minerals, which,

under ordinary temperatures to which water is subjected, are in no respect changed, may be completely altered by water confined in strong vessels and heated to dull redness. Silicates, aluminates and calcareous matters in the amorphous condition, may not only be made crystalline, but their degrees of hydration may also be permanently altered; and he also mentions the production of anthracite by a similar process, from wood. Indeed, the changes both of structure and chemical constitution, which may be produced in this manner, are very great, and extend, in all probability, to nearly the whole range of mineral matters found in the rocks.

Now, if as is generally believed and accepted, these are the changes in progress, while rocks are undergoing metamorphism, then, in all probability, the rocks are undergoing at the same time *a change in their specific gravity*. It is highly probable, if water is the chief reagent, and if it constitutes a change both chemical and physical, that the specific gravity of the mass, into which it enters, is not the same as it was before such a change took place. But if we admit this, then we have also admitted that the volume of those rocks has either increased or diminished. If we assume it to have increased, there must take place an expansion, and such an expansion must necessarily be upward. For, beginning at the lowest level, at which any such change may be assumed to supervene, the total weight of the superincumbent mass is the same as it was before, and hence there would be no change at that level. Nor could there be lateral expansion of any importance; all expansion would of necessity be vertically upwards. On the other hand, a decrease of volume would occasion a subsidence for converse reasons.

If we were to assume a change in the specific gravity of 1000 feet of rock, to the extent of five per cent., we could account for a change of level of 50 feet, and a series of rocks as thick as the carboniferous in this State, would, with an equal amount of change, give an alteration of level equal to the average attitude of the North American Continent above the ocean. It is, of course, impossible to conjecture the depth to which metamorphic action may extend, though it is undoubtedly very great; at least eight or ten miles, and there might be no great improbability in supposing such changes to take place through a large portion of that depth at the same time.

That the rocks far down below the surface take up under the influence of great pressure, aided no doubt by heat, large quantities of water, carbonic acid, sulphydric acid, and perhaps other electro-negative agents, is manifest in the materials issuing from volcanoes and from thermal springs. Water and gaseous acids issue in such enormous quantities from volcanoes, as to constitute a large fraction of the entire mass delivered, indicating that the solid materials have become super-saturated with them, and the association is resolved as soon as they reach the surface of the earth, and are relieved of the pressure to which they have been subjected.

The overflow of volcanoes would, it is suggested, be susceptible of a similar explanation. Let us suppose a stratum or two, situated a few miles

below the surface, became softened or lightened by the combined agencies described, so as to be specifically lighter than the average mass of over-laying rock. If a vent or fissure could be found, such a plastic mass would inevitably follow the laws of the equilibrium of fluids, and would not only rise up into the chasm, but overflow. Putting the problem into another form, the heavier over-lying mass would sink into the lighter semi-fluid beneath, and drive it upwards. It is a well known fact, that the lavas are all of small specific gravity. Indeed, were it otherwise, Lieut. Dutton thought that the overflow of a lofty volcano like Ætna or Mauna Loa, would be impossible; for a column of dense material of such a height, exerting its pressure upon its subterranean reservoir, would raise the overlying strata, instead of rising above them. But, in truth, the superior strata are doubtless heavier, and exert a greater pressure upon the reservoir than the lava itself.

In a similar manner Lieut. Dutton sought to explain the intrusion of traps, trachytes and basalts. These rocks were probably lighter than those which originally overlaid them, and forced their way through weak places to the surface. The traps, basalts and porphyries,—at least such porphyries as may be called intrusive—though they are unquestionably altered sediments, are for the most part amorphous, and not crystalline. They were evidently altered at a comparatively low temperature, and at no very great depth. They do not appear to affect the strata into which they are intruded, and withal, are less highly metamorphic than gneiss or marble. Water seems to have been the chief agent in their transformation, and they may have been forced upward in a soft condition, and upon being relieved of the pressure, parted with the greater portion of this water. The traps and basalts also exhibit many planes of cleavage, with very perceptible interstices, and these interstices would seem to be much wider than could be accounted for by the contraction of cooling. He stated that he had often noted this fact, and was decidedly of the opinion that the contraction of these rocks by loss of heat, could by no means account for the entire width of such plans of cleavage, and believed that it was in great part due to the loss of water, which had once rendered them plastic.

If these views be correct, then we ought to expect that volcanic regions will be confined to those areas which have recently been regions of marked elevation. And we find this to be the case. In America, the whole extent of the Rocky Mountains and of the Andes, so far as known, was covered by the ocean at the beginning of the Tertiary period. The elevation of the Rocky Mountains was probably earlier than that of the Andes, and sooner completed. Hence, while the former was the scene of an unparalleled amount of volcanic action during the Pliocene and Miocene, and is now nearly, or quite, quiescent, except in Southern Mexico, the Andes still abound in active volcanoes. The East Indian volcanic regions are all of Tertiary formation, as are those of the Mediterranean and the Auvergne.

PRELIMINARY REPORT ON THE VERTEBRATA DISCOVERED IN THE PORT KENNEDY BONE CAVE.

By Prof. E. D. Cope.

(*Read before the American Philosophical Society April* 7, 1871.)

My friend, Charles M. Wheatley, has already given an account of the discovery of a fissure in the Potsdam limestone of Chester Co., Pennsylvania, containing the remains of numerous animals and plants of the Postpliocene period (see Amer. Jour. Sci. Arts, 1871, April). Dr. Quick, of Phœnixville, having brought to his notice mastodon remains exposed in quarrying the limestone near Port Kennedy, he visited the spot, and determined the existence of the fissure and its contents. In the article in question he describes it as situated near the line of junction of the Triassic red sandstone. Its depth is nearly fifty feet, and the greatest width thirty; at the summit or surface of the limestone, its width is twenty feet. It is filled to a depth of forty feet with the debris of the neighboring Triassic strata, of a red color; below this point is a bed of tough "black clay eighteen inches in thickness, filled with leaves, stems, and seed vessels of post-tertiary plants. Scattered through all this mass of vegetable remains, and also in a red tough clay underneath for six to eight inches in depth, are found the fossils noticed in this paper."

Mr. Wheatley furnishes a list of the species we had identified up to the time of writing, viz.; twenty-seven vertebrata, ten coleoptera, and ten plants. These numbers have been considerably increased up to the present time, and I look to a much fuller and more complete exposition of the Postpliocene vertebrate fauna, in consequence of a more thorough examination of the remaining part of the fissure, by my friend, C. M. Wheatley.

As regards the position of the remains, the article above quoted, proceeds to state that "the remains of Mylodon, Ursus, and Tapirus have been mostly obtained from the tough red clay directly under the plant bed, but the remains of rodents, snakes, tortoises, plants, and insects, are entirely confined to the plant bed. Neither the bones nor the teeth are rolled or water worn, but all are sharp and well defined." The appearance of the specimens corroborates the above statements. I would add some exceptions. Thus two of the specimens referred to *Arvicola sigmodus* came from the red bed, and one from the black; one *Megalonyx wheatleyi*, came from the black bed, the others from the red. Milk teeth of Mastodon occur in the red bed also. General remarks are deferred to the close of the report.

Megalonyx, Jefferson.

The remains of species of this genus found in the fissure are more abundant and striking than those of any other. At least fourteen individuals are represented by the bones and teeth obtained. These belong probably to five species, as described below, four of them different from

those hitherto known, three of them of a size equal to that of the *M. jeffersonii*, the others smaller. These species are only certainly distinguishable at present by the teeth, as the other bones are very similar to those of other species, so far as preserved.

The teeth consist of eighteen canine, and nineteen molar teeth, whose characters are discussed below. The bones are chiefly those of the feet, with portions of long bones, and numerous vertebræ. Cranial bones are in most instances destroyed, for though several complete crania were exhumed, the exposure to frosts and thaws with snow and rain, as they laid in the piles of material, disintegrated them. Of limb bones there are the extremity of a large tibia with cotylus for astragalus, several extremities of fibulæ, and some broken heads of femora.

Of the bones of the fore limb there are three unciforms, two magnums, and fifteen metacarpals with numerous phalanges. The bones of the hind limb include three astragali, seven cuboids, six scaphoids, and five incomplete metatarsals. The phalanges of both fore and hind feet, which much resemble each other, number thirty-two, of which nine are ungueal. Of vertebræ, no cervicals have been found, except an axis without neural arch. Caudals are most numerous; some of the vertebræ have coössified epiphyses, others not, indicating various ages. I have counted twelve individuals from the teeth, but it is quite possible that there are others represented by some of the bones.

The canine (molar) teeth present a remarkable variety of forms. As is known, the section of the crown is oval, on one side concave with a more or less prominent swelling interrupting it. The differences are seen in the development and position of the broad rib of which the swelling is a section, in the curvature of the shaft, and greater or less obliquity of the grinding surface.

There are three types of form among them as follows:

1st. The shaft curved, the triturating surface oblique, the internal longitudinal rib prominent, nearer one end of the crown than the other, dentine of inner side thickened anteriorly; two specimens.

2d. Shaft nearly straight, triturating surface transverse (in its long direction); rib of inner face median, prominent; dentine of inner side uniformly thin.

3d. As in the last, but the shaft more compressed, therefore the section narrower, the inner bulging rib being very low and insignificant.

The first of these represents a species distinct from those of the other series; one nearer the *M. jeffersonii*, and of large size.

In studying the present genus I have been under many obligations to Dr. Leidy's Memoir on the Extinct Sloth tribe of North America, published by the Smithonian Institute in 1855. In it the species *Megalonyx jeffersonii* is established for the first time on a solid foundation, and the characters, especially of the dentition, clearly pointed out.

Megalonyx loxodon, Cope, species nova.

The two teeth of the first type may, perhaps, be superior ones; their curvature accounts for the obliquity of the grinding face in the long

direction. This curvature is seen in teeth of *M. jeffersonii* (See Leidy's Memoir on Extinct Sloth tribe, Pl. VI., figs. 4-6), which do not appear to be straight in the maxillary bone at least, at any time. These teeth differ from those of *M. jeffersonii* in having the posterior margin thinned out, while the anterior is thickened by the near aproximation of the interior rib. In the larger of the two the posterior margin is slightly incurved, the exterior convexity thus produced opposing that of the anterior face and inner rib, as one short side of a romboid does that opposite to it. The section of the smaller differs in the shortness of this intero-external face, and is thus rounded subtriangularly and antero-internally, as described by Leidy in the *M. jeffersonii*, and thus different from that seen in the *M. wheatleyi*. The external face has an open longitudinal concavity, The triturating surface in both teeth is a longitudinal groove; in the larger, the inner margin is highest anteriorly, the outer highest posteriorly.

These teeth I suppose to represent a species different from the *M. wheatleyi*, and perhaps from the *M. jeffersonii* also, as none of the sections given by Leidy (l. c. Pl. XVI), approach their form. The nearest is his fig. 3, where the section of the bulge is not quite central.

MEGALONYX WHEATLEYI, Cope.

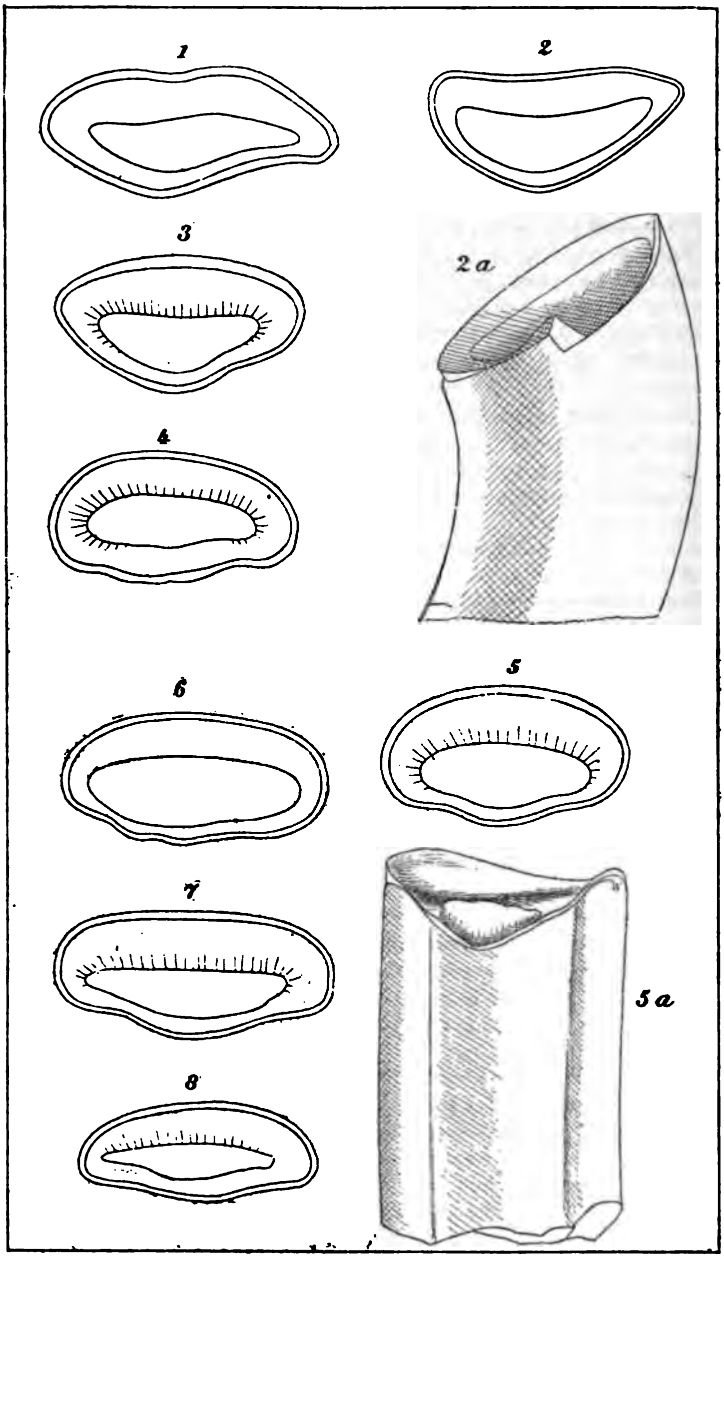
Species nova.

Represented especially by fourteen canine and sixteen molar teeth, but probably also by the greater part of the bones above mentioned. The former are referable to eight individuals, to which perhaps four others should be added.

The characters of the species are chiefly visible in the molar teeth, which in the maxillary bone are acutely trigonal instead of triangular ovate as in the *M. jeffersonii*; and in the dentary bone, transversely, sometimes narrowly, parallelogrammic, frequently narrower internally than externally. In the *M. jeffersonii* the latter are almost as broad as long, of equal width, and with the inner or outer margin slightly oblique.

In the *canine-molars* before mentioned of the second and third types, we have but little or no curvature of the shaft, no longitudinal grooving of the outer face, the outer dentinal wall uniformly higher on the triturating surface than the inner, and the long diameter of this face but little oblique to the transverse plane of the shaft. As both superior and inferior molars corresponding in size, color, and number to these teeth have been found, I suppose the latter to have been derived from both jaws.

The differences in these teeth are to be seen in the different degrees of development of the dentine layer, and of the bulge on the inner face, and of the degree of compression of the shaft. Five of the best preserved exhibit the thickness of the external layer continued round the extremities of the grinding surface, and then rather abruptly contracting wedge like, into the thin layer of the interior face. In two other teeth this contraction takes place at the external curves, and is less in degree, the inner


1
2
2 a
3
4
5
6
7
8
5 a

layer being more uniform. In two teeth the dentine of the bulge of the inner face is very nearly as thick as that of the outer (F. 4). As regards the form, in the last mentioned tooth the bulge is well developed (as in Leidy's Pl. XVI. fig. 1), and the shaft is not compressed. In the two previously mentioned, the shaft is short and the bulge very low and bounded by two shallow grooves; in one (F. 6) (which is accompanied by the posterior molars), it has a shallow median groove. In the five canine molars first named we have every degree of compression. In one (F. 3) the shaft is stout, and the bulge larger than in any other, about as in Leidy's Pl. XVI. fig. 2; in a second (F. 5) the shaft is similar, with low bulge, like fig. 7. l. c. In the third (F. 7) from a large individual, there is more compression, and the bulge is very low; the last two are similar, but smaller; they belong apparently to opposite sides of the same animal (F.8). These are like the tooth figured and described by Dr. Leidy as that of *Megalonyx dissimilis.*

I am inclined to refer the teeth of these types to one species, a view confirmed by a study of the molars. They are all stained yellowish or light rust color except one, which is black, and which is associated with three posterior molars of similar color and corresponding size. The remaining posterior molars are of the color of the other canine molars, and no doubt belong to the same individuals in part, but none can be associated with the same certainty as the black specimens. On the light colored posterior molars I propose to establish the *Megalonyx wheatleyi*, since I should scarcely distinguish it from *M. jeffersonii*, or *M. dissimilis* by the canine-molars alone. There can be no question that the forms of these teeth, characteristic of the two supposed species, graduate into each other; the characters derived from the development of the interior enamel plate, may be distinctive, but in that case there is at least one other undescribed species in the series I have explained above. *M. dissimilis* it appears to me must repose on the posterior upper molar, which Leidy shows to be transversly oval and not triangular in section. That tooth is as triangular in *M. wheatleyi* as in *M. jeffersonii.*

From the preceding, it is probable that the most allied species of *Megalonyx*, cannot be exactly defined by the characters of their canine molar teeth, though, as in many species of Mammalia, they may be indicated by the extreme forms of those teeth, the range of variation overlapping.

The *superior-molars* (1a) belong to at least three (perhaps four) individuals. They are nearly straight trilateral prisms, so worn that the inner anterior angle is the most elevated. The anterior dentinal plane is slightly convex, the posterior concave to a less degree. The exterior angle is much less obtuse than in *M. jeffersonii*, that enclosed by the dentine being prolonged and very narrow. There is a notable difference between the two posterior molars of the superior series, preserved. One belongs to the individual stained black. Both are slightly bowed posteriorly, and both have a subtriangular section, the apex directed inwards.

In the light colored specimen the outer face is wide and nearly plane, the anterior very slightly convex, and the posterior concave, making an open longitudinal groove; the external angle is obtuse. In the black specimen the inner face is narrower, the anterior more distinctly convex, and the posterior convex also, rounding off to the more obtuse external angle. Both these teeth are worn obliquely as in *M. jeffersonii*.

The wearing of the median molars is transverse to the axis of the shaft anteriorly, oblique to it or descending inwards, posteriorly. The wearing in the long axis of the jaw bone, is obliquely forwards on the posterior dentinal wall, and divided on the anterior, one half sloping forwards and the other backwards, the slopes separated by a sharp ridge of the dentine.

A single tooth, which by its form is excluded from a place in the mandible, and by the character of the wearing of its crown, can be none other than the second molar, or first of the regular series. Its form is very different from that of the same tooth in *M. jeffersonii*, but is appropriate to the modification described below as characteristic of the inferior molars of *M. wheatleyi*. There is no anterior wear on the anterior dentinal plate, indicating the absence of any tooth anterior to it in the inferior jaw; this plate is much higher than the posterior, which has two worn surfaces, the anterior horizontal, the posterior oblique. The middle of the crown is concave, and the concavity is carried across the dentine of one end. The tooth is in section a transverse parallelogram with the outer short side oblique, instead of parallel to the inner. Anterior face slightly concave, posterior slightly convex.

The characters of the *inferior molars* are established by three posterior in place in the fragments of jaw held together by the matrix of red sand and clay. That they might be the superior series of another species is suggested by the subtriangular outline of two of them, and the jaw is so fragmentary that it is not sufficient to decide the case. The following points, however, are conclusive. If they were superior, the terminal teeth must be either the second or fifth molars, according to the relation to front or back in which they are viewed. That neither can occupy this place is proven by the following description:

The anterior is a rather narrow transverse parallelogram, with the sides and angles rounded. The posterior dentinal plate is worn transversely, the opposite one is oblique, descending to one side. The form is worn obliquely away from the centre of the crown, the latter is plane. The next tooth is a parallelogram narrowed towards one end, which is rounded obliquely to the other sides; it is narrower than the last, and the dentinal plates are worn in exactly the same way. The last tooth is much wider than the others, and has a subtriangular outline, the narrow end very wide and obtuse, and on the same side as the narrowed end of the one in front of it. The outline is worn in the same manner, except that the angle at one end of the base of the triangle is, perhaps, more elevated.

(1.) Neither of the extremital teeth have the oblique face of the pos-

terior one of the known species of *Megalonyx*, nor the reduced size, so that it remains to ascertain whether either of them is the first superior molar. (2.) The larger is evidently not so, because it has an obliquely-worn distal face, indicating the existence of another tooth beyond it in the opposite jaw. (3.) The opposite one is not the anterior molar, because (a) its anterior dentinal face is worn horizontally, not obliquely backward, indicating an overlapping tooth; (b) because the oblique wear of the dentine would, on the supposition that it is the first, be thrown on the posterior instead of the anterior faces of the other molars; (c) and because its form is narrower than the other teeth, instead of wider as in other species.

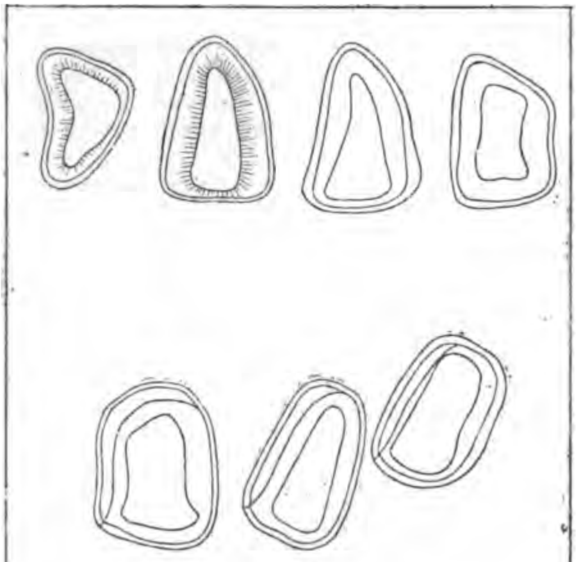
Confirmatory of this conclusion is the fact that no palate can be discovered among the fragments where it should be, were these teeth maxillaries. The question as to the relation of ends is settled by the fact that the plane of the crowns rises to the narrower, which would thus be anterior. Also the large tooth has the oblique surface for the last superior molar, which the anterior has not. The fragments of the jaw indicate the same thing, rising (towards the coronoid process) at the large tooth and falling at the narrower. The latter, then, for the above reasons, I assume to be the anterior.

	M.
Length of three juxtaposed crowns	0.053
" anterior crown, inner end	.013
" " " outer end	.013
Width " "	.02
Length of last " outer end	.014
" " " inner end	.0016
Width " "	.02
Length of shaft first tooth	.054

There are five isolated molars of the same type as the above. Three of these are evidently anterior or second inferior molars, two of the left side and one of the right. Their section is suboval, and all the details, size, &c., are as above described. Two others are like the second (or third) inferior molars. One of these is peculiar in being a little concave on the anterior face, the inner extremity very oblique, the other is more oval.

The question as to the *specific relations* of these inferior molars may be stated as follows. Their large size precludes the probability of their belonging to either *M. tortulus* or *M. sphenodon*. They appear to belong to one species, without doubt. The superior molars also belong to one species, and as no other species is represented in any thing like the same abundance, it is reasonable to suppose that these, with the most abundant of canine molars. belong to the same form of Megalonyx. The canine molars differ from those of *M. loxodon*, and the posterior upper molars from those of *M. dissimilis*. The disproportion between the sizes of the second and last inferior molars, with the narrow oval and triangu-

lar forms of the same, separates the animal from the *M. jeffersonii*. The only known molar of *M. validus*, Leidy, is like nothing found in the present species, and *M. rodens* and *M. meridionalis* each have their peculiar features. I therefore call the present animal *M. wheatleyi*.



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Another molar, perhaps the third inferior of the three, is larger, and appears to belong to another individual; it is a little wider inwardly, and resembles Leidy's fig. 13 of Pl. XVI., except in its narrower angle and perfect symmetry. It may belong to *M. wheatleyi*, but the outer angle is regularly rounded; it may be *M. sphenodon*. It differs from those of *M. jeffersonii* as the *M. wheatleyi*, in the greater extension in a transverse direction, and in the concavity of one of the long sides. The enclosed area of osteodentine is in section a frustrum of a narrow triangle, instead of rounded parallelogrammic as in *M. jeffersonii*.

Measurements of teeth.

	M.
Long diameter, (Fig. 5) light cold. canine molar	0.0316
Short " " "	.018
Long " of (Fig. 3) " "	.0325
Short " " " "	.019
Long " of (Fig. 6) black "	.035
Short " " " "	.017

Long diameter of (Fig. 6) black super. molar					.021
Short	"	"	"	"	.015
Long	"	(Fig. 9) light,		"	.0215
Short	"	"	"	"	.0158
Total length			"	"	.062
Long diameter 4 super. molar of (Fig. 6)					.017
Short	"		"	"	.011
Long	"		"	(Fig. 9)	.018
Short	"		"	"	.0129
Long	"	inferior molar		(light)	.0223
Short	"	"		"	.015
Length	"	2d "		(loose)	.0214
Width	"	"			.015

There are *vertebræ* of both adult and young animals. An axis is much like to that described by Leidy in *Megalonyx jeffersonii*. The centrum is much depressed, with a strong inferior keel. The articular faces of the lateral abutments and of the odontoid process are continuous. This process is short and conic, and is a continuation of a projection of the centrum, which is notched on each side above, at its anterior limit, for the annular ligament. A more posterior cervical, with coössified epiphyses, is much less depressed, and is about as broad as long. A caudal, with coössified epiphyses, has subround articular extremities, and is remarkable for the extent of the chevron articulation of both ends of the inferior aspect. These are connected by a lateral ridge which encloses a deep fossa.

Measurements of Vertebræ.

	M.
Length axis	0.089
Greatest width	.096
" neural canal	.035
Width centrum behind	.044
Depth "	?? .028
Length poster. cervical	.054
Width " articular face	.0565
Depth " "	.05
Lengh caudal	.052
Width " articular face	.057
Depth " "	.05
" " young, larger animal, with separate epiphyses	.083
" articular face, dorsal of young	.05
Width " "	.062
Length centrum of "	.0455

The *carpals* do not present marked difference when compared with those figured by Leidy under *M. jeffersonii*. Among the *tarsals*, one astragalus is exactly like that of the latter species; another is deeper and shorter, viewed from the inner side, with vertical truncation below in

front, and much deeper superior ligamentous pit. Of the scaphoids, two probably of the same animal, are deeper posteriorly, and with the convex part of the superior articular face rounded; four others are flatter, two with the articular face above rounded, and two subconical. The cuboids differ in the degrees of depression of form. Two are more depressed, three larger less so, and one still less.

The *metacarpals* are all present, and belong to several animals. There are four of the first, which appear to have belonged to two species. Three exhibit the articular extremity as very oblique to the superior plane of the bone, and including a groove between it and the surface of attachment to the 2d metacarpal. The inferior surface exhibits a swollen knob, and a pit behind it. The fourth is nearly plane above and below, with the articular ginglymus at right angles to both, and articulation to second metatarsal also at right angles to them. No groove between these surfaces, but a regular concavity. Outer extremity not projecting as in the first. The other metatarsals have the form and proportions already described by Leidy.

				M.
Length	of Metatarsus	I		.045
Width	"		posteriorly	.036
Length	"	II,		.059
Depth	"		"	.052
Length	"	III,		.0945
Depth	"		"	.057
Length	"	IV,		.104
Depth	"		"	.05

The phalanges are like those figured and described as belonging to the *M. jeffersonii*. Many of them are the proximal ones of greatly shortened proportions, characteristic of the sloths. The penultimate are of various sizes, an average one measures as follows:

	M.
Length	0.071
Depth behind	.045
Width "	.037

But the following measurements of a proximal phalange indicate an immensely large example.

	M.
Length	0.031
Depth behind	.062
Width "	.053

The *ungueal phalanges* are compressed and curved, with obtuse rounded superior margin. Only one exhibits a tendency to the acute superior margin characteristic of those typical of *M. jeffersonii*, though claws of both kinds have been ascribed to the latter. The inferior plane is gently convex. The insertion for flexor tendon is expanded laterally

over the origin of the nutritious foramen on each side, into a shelf: general form longitudinal oval. The superior direction of the median radius of the cotylus for the last phalange, shows that the claws were always flexed to some degree.

Fragments of many long bones, including many condyles, accompanied the above, but in the lack of certainty as to their proper reference, are not described.

This species is dedicated to Charles M. Wheatley, of Phœnixville, to whom Natural Science in the United States is under many obligations. The expense and much labor requisite for the proper recovery and elucidation of the remains contained in the cave are entirely due to his liberality and exertions. Similar devotion to Science has preserved to us the finest series of fossils of the triassic period of the Northern States in existence, and the finest collection of fresh water shells in America.

Megalonyx dissimilis, Leidy.

Proc. Acad. Nat. Sci., Phila., 1852, 117. Sloth tribe N. A., 45, Pl. xiv., figs. 4—8, xvi., 8 and 15.

Probably represented by three canine molars, which belong to at least two individuals. They have been described under head of the preceding species (see 1 a c). The canine molars are the only ones which can be compared with Leidy's figures and descriptions, with which they agree closely.

Measurements of teeth.

	M.
Long diam. canine molar, larger individual of 1 a c..............	0.036
Short " " " "	.0158
Long " " smaller "	.032
Short " " " "	.014
Length shaft " " "	.079

This species is evidently about the size of the *M. wheatleyi* and *M. jeffersonii*.

Megalonyx sphenodon, Cope.

This species is the smallest of the genus yet known from North America. It is indicated certainly by the canine-molars of opposite sides of one individual only.

These teeth are flat and a little curved. A principal peculiarity consists in the regular increase in their diameter, from the apex to the base, in both the longitudinal and the transverse directions. The long diameter of the triturating surface is four-fifths that of the base where broken off. The dentinal layer is thick externally ; it contracts after turning, and the layer of the inner aspect is uniformally thin, but less so than in *M. dissimilis*. The inner bulge is well marked, and is a little nearer the anterior margin than the posterior; the latter is the thicker. The triturating surface is slightly oblique in the long direction, as in the two species

preceding this, and concave transversely ; the inner dentinal plate being worn much lower than the outer. Exterior face of tooth regularly and gently convex.

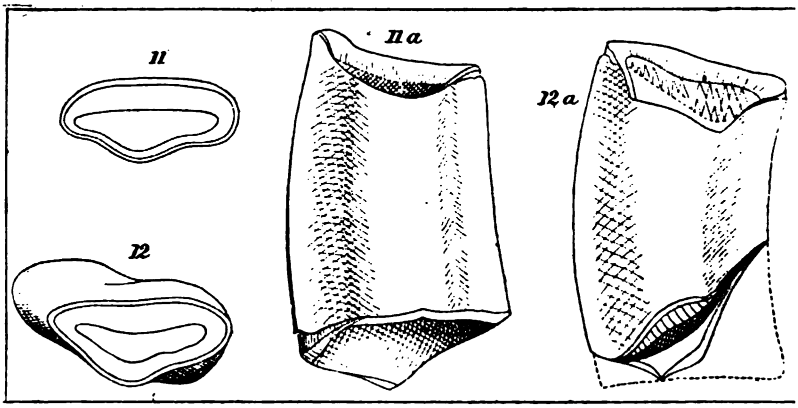
	M.
Length of fragment of tooth	0.044
Long diameter at grinding face	.025
" " " base fragment	.0275
Short " " " "	.0148
" " " grinding face	.0125

The question has naturally arisen, whether this tooth has not belonged to a young animal of *M. wheatleyi* or *M. jeffersonii.* Its small size and subconic form would suggest this view. Teeth of the monophyodont type, generally possess the character of those of the successional type, in being protruded of the full size, and not increasing in diameter with age. Exceptions, however, occur in some *Rodentia*, as the beaver. It has however, never been seen among the numerous teeth of sloths, which have been studied by authors, while a genus allied to *Mylodon*, *Sphenodon* of Lund, presents this character at maturity. Further, the most expanded portion of these teeth presents considerably smaller dimensions than the smallest of the *M. jeffersonii*, figured by Leidy ; the diameter of the triturating surface is only .66 of that of the same, (Leidy, l. c. xvi, fig. .6).

In the moderate development of the inner bulge, these teeth are like some of those of *M. wheatleyi.*

MEGALONYX TORTULUS, Cope, sp. nov.

Established on two corresponding canine-molars of opposite sides of a sloth, found in association with the preceding. These teeth are more dis-



tinctly curved than in the three species preceding, but are more as in *M. jeffersonii* and *M. loxodon.* Its shaft possesses a peculiarity of the latter, which is not seen in *M. wheatleyi*, *M. dissimilis* and *M. sphenodon*, i. e., it

is twisted, so that the vertical plate of the triturating surface is quite oblique to that of the basal portions of the shaft.

The triturating surface is, in its long diameter, transverse to the margins of the tooth adjacent; the short diameter is very oblique. The bulge is well marked, and in the specimens a little anterior to the middle. The inner layer of dentine is thickest anteriorly, where it is but a little narrower than the thick external layer, but it is nowhere very thin. The outer face is concave, a feature not seen in the three species above mentioned, and not exhibited by any of the sections of the teeth of *M. jeffersonii* given by Leidy, l. c.

	M.
Length of fragment of tooth	0.043
Long diameter grinding surface	.0232
Short " " "	.0145

These dimensions show that the *Megalonyx tortulus* is not larger than *M. sphenodon*, perhaps not so large, as the diameters of the apices of their teeth are identical, while that of the base is equal to the apex in the former, greater in the latter. The concavity of the outer face, and disposition of the dentine, are entirely different from that seen in *M.* and *sphenodon* other species, and more as in *M. jeffersonii* and *M. loxodon*.

For the better discrimination of these species, the following synoptic table of dental characters is added.

A Canine-molars, much curved, of equal diameter.

Large, bulge median; grinding surface oblique.	*M. jeffersonii.*
Large, bulge anterior; grinding surface a groove.	*M. loxodon.*
Small, concave externally.	*M. tortulus.*

B Canine-molars little curved, of uniform diameter.

Molars triangular, canine-molars less compressed, large.	*M. wheatleyi.*
Last molar oval, canine-molars more compressed, large.	*M. dissimilis.*

C Canine-molars little curved, diameter contracting to the apex.

Bulge median, dentine thin within, small.	*M. sphenodon.*

Mylodon, Owen.

Mylodon ? harlani, Owen.

The remains representing this genus are not sufficiently characteristic to enable me to determine the species with certainty. They consist of two imperfect ungueal phalanges, and the distal extremity of the tibia. The former indicate a very large animal; they are stout, convex above, with lateral ridge and three basal plates. The flexor insertion is broad and flat, the foramina well developed. In the second phalange the middle inferior plane is represented by an obtuse angle. The tibia presents the excavation for the astragalus, as in *M. robustus* Ow,* but is narrower or with less anteroposterior diameter than in that species.

*See Owen on Mylodon. Pl. xx fig. 4.

Measurements.

	M.
Long diameter end of tibia	0.135
Short " " " (transversely)	.08
Vertical diameter ungueal phalange at nutritious foramina	.053
Transverse " " " " "	.037

These claws are similar to those of the *M. harlani* which have been discovered.

SCIURUS, Linn.

SCIURUS CALYCINUS, Cope.

Species nova.

Established on two imperfect rami of the under jaw, with the incisor and first, second and third inferior molars *in situ*. The size approximates it to the *S. hudsonius*, and exceeds that of the *S. panolius*. The forms of the ramus so far as visible, is not unlike that seen in the same squirrel. The characters which distinguish it from *S. hudsonius*, are chiefly to be seen in the molar teeth, especially the anterior. The crowns of all are deeply cupped, and the tritruating surfaces form anterior and posterior narrow bounding bands, which widen outwardly. The margin of the tooth is elevated and entire, except externally, where the two usual low cusps are separated by a deep notch. In the *S. hudsonius* the interior and exterior margins are both emarginate, each notch supporting a median cusp, thus forming three on each side. The anterior molar exhibits this character still more strongly. Its crown is a cup as wide as long, with high uninterrupted margin, except on the outer side, where it is deeply notched, It has but two roots. In *S. hudsonius* this tooth has three roots, is longer than wide, and has three marginal cusps on the inner and outer sides of the crown.

Length of three crowns m. 0048; length exserted portion of inferior incisor m. 007; transverse diameter do. at point of issue m. 0023.

From the extent of the worn surfaces of the molars, the animal described is adult. The second ramus is of the same size; the dental series is complete, and the teeth are worn so as to present a dentinal area surrounded by a thin margin of enamel. The outlines of the teeth are like those of the first specimen.

As compared with *S. panolius*, the species is larger, and differs in the form of the m. 1, as much as in the case of *S. hudsonius*.

JACULUS, Wagler.

JACULUS ? HUDSONIUS, Zimm.

One ramus mandibuli with incisor and second molar preserved. The latter nearly resembles the figure in F. Cuvier's Dents des Mammifers, and the ramus is about the size of that of the existing jumping mouse. Nevertheless, in lack of specimens of the cranium of the latter, I am unable to determine its specific relations, now first found in the Postpliocene.

Hesperomys, Waterhouse.

A ramus with first and second molars and incisor, agreeing in details of structure, with the group with which our recent *H. leucopus* is type, and of the size of that species, not certainly referable to the latter, without further comparison.

Arvicola, Lacep.

Remains of species of the genus are numerous in all the cave formations of the United States which I have examined. Those obtained by my friend, C. M. Wheatley, are referable to three sections of the genus, one of them the group Pitymys, as defined by Prof. Baird,† the others new; one intermediate between Arvicola and Pitymys, and third an exaggeration of the peculiarities of the last. They are defined as follows, the character of the sub-genus Arvicola being added for comparison.

Arvicola, Lac. Anterior lower molar triangles 1 $_2{}^3{}_3$, 1 three lobed; middle lower, 1 $\frac{2}{2}$; middle upper, 1 $\frac{2}{2}$.

A. riparia, Ord.*

Isodelta, Cope. Anter. inf. molar, 1 $\frac{2}{2}$; 1 three lobed; 2d inf. mol. 1 $\frac{2}{2}$.

A. speothen, Cope.

Pitymys, McMurtrie. Ant. inf. mol. 1 $\frac{2}{1}$ 1, lobed; 2d inf. mol. 1 $\frac{1}{1}$ 1.

A. pinetorum, Lec. *A. sigmodus*, Cope. *A. didelta*, Cope. *A. tetradelta*, Cope.

Anaptogonia, Cope. Ant. inf. mol. 1 $\frac{4}{3}$, 1 several lobed, the triangles all connected medially, the posterior nearly enclosed.

A. hiatidens, Cope.

The third group is represented by the greatest number of individuals and species.

Arvicola speothen, Cope.

Sp. nov.

This species is represented by the entire dentition of the left ramus mandibuli, with a few fragments of the adjacent bone. As already pointed out, its characters entitle it to rank as a distinct section of the genus. Thus the triangles of the inner side of the anterior inferior molar are one less than in any species of the section *Arvicola*. The anterior loop presents two well marked angular basal areas, while its terminal portion is regularly rounded. The accompanying outline will give a good

†I have depended on Prof. Baird's well known work in studying this genus.

*Arvicola riparia, Ord.
Baird, U. S. Pac. R. R. Surv, viii, 522.
This species has not yet been found in the Port Kennedy cave, and I introduce it for the purpose of recording its occurrence in the cave breccia, Wythe Co., Virginia, whose contents I examined and described in Proc. Am. Phil. Soc., 1869, 171. It is represented by a left ramus mandibuli, entire except in the angle and condyle, and with complete dentition. The size and proportions are identical with those of the existing species, as are also the triangles and form of terminal trefoil lobe of the anterior inferior molars. There is no difference to be observed between the third inferior molar when compared with that of *A. riparia* from Pennsylvania, but the anterior alternate triangles of the second, are not isolated, the reëntrant inflection of the external enamel plate not reaching the internal, as in the recent animal.

idea of its form. That this is not one of the species of *Pitymys*, in which the basal lobe of the anterior trefoil has been cut off by unusual inflexion of the enamel angle, is demonstrated by the structure of the second molar, which is precisely that of typical *Arvicola*, all the triangles from the posterior being isolated and alternating, producing the formula, $1\frac{2}{2}0$. The third molar has the usual formula, 1-1-1, the posterior two lobes being crescentic, the anterior trapezoid.

Measurements.

	M.
Length grinding surface inferior molars, (No. 1)................	0.0068
" " " 1st " " "	.008
" fang and crown " " " "	.005

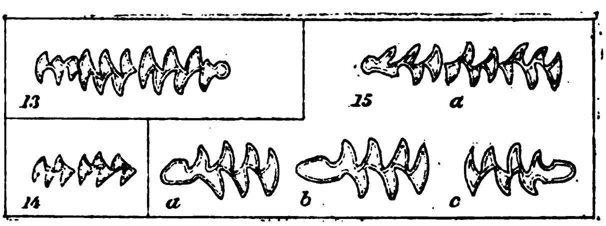
The structure of the molar triangles, i. e., their acuteness and thinness of enamel, induces me to describe here, without any certainty of reference, the superior molar teeth of one individual found near the same time. The formulae of the superior molars are (1) $1\frac{4}{2}$, (2) $1\frac{4}{2}$, (3) ? this, so far as known, identical with that of *A. didelta*. In another specimen represented by incisor and sup. m. 1., the former has an oblique antero-external face, with narrow truncate outer face; enamel not striate, emarginate at the cutting edge. In *A. didelta*, (fossil, below), the antero-external face is more oblique, and without defined external plane; the end is not emarginate (in one specimen). This tooth appears to be relatively smaller and weaker in the ?*A. speothen*.

	M.
Length fang and crown, 1st superior molar (No. 3)...............	.004
Width enamelled face incisor " "	.001

ARVICOLA TETRADELTA, Cope.

Sp. nov.

Represented by a portion of the cranium, which embraces the 2d and 3d superior molars, and parts of the m. 1, and incisor. The formula of the



two molars perfectly preserved is $1\frac{1}{2}$, $1\frac{3}{2}$. The terminal triangles are as well developed inside as outside; the others are rather small and obtusely angulated. Those of the m. 3, are entirely separated, and the last is not followed by a loop, but is completely enclosed behind by the vertical enamel plate, which bounds the corresponding triangle in the m. 2. This is a character which distinguishes this species from any other of the

genus Arvicola which has been described from North America, of which the corresponding tooth is known. The last triangle is slightly angulate in posterior outline.

	M.
Length grinding face of m. sup. 2 and 3.	0.0037

It is only necessary to compare this species with the *A. speothen* and *A. involuta*, in which, unfortunately, the corresponding tooth is unknown. Its small and obtuse triangles distinguish it from the former. As reduction of the terminal loop of the m. inf. 1 is characteristic of the latter, the present tooth might be suspected to belong to it, but there is a real increase in the number of triangles over that of the most nearly allied species. *A. didelta*, and of the section *Pitymys*, to which it belongs, pointing most to the sections *Isodelta* or *Arvicola*. Size, .25 less than A. speothen.

Arvicola didelta, Cope.

Species nova.

Represented by the mandibular rami of five, and superior dentition of probably three individuals. One imperfect cranium contains the dentition of both jaws, thus fixing the relations of fragmentary specimens, especially in the more important relation of the anterior, inferior and posterior superior molars. The characters of these show that it is allied to the *A. pinetorum*. The accompanying cuts illustrate the form of the first inferior molar tooth. The ridges are four internal and three external. The second molar exhibits the formula $1\frac{1}{1}1$, the anterior area with an approach to division into two triangles, alternating. This peculiarity is not seen in Prof. Baird's figure of *A. pinetorum*, l. c. liv. 1719, nor does the latter represent the loops of the last molar, as exhibited by our specimens. In the figure they are oval, in our specimens angulate crescentic. As the figure does not agree with the description, I do not rely on it for these details.

A more important difference is seen in the structure of the superior third molar, which Baird describes and figures as having but three isolated areas, the lateral angles being sub-opposite and confluent medially. In *A. didelta*, there is an internal and an external triangle, each entirely isolated, besides the anterior and the posterior loops. The last differs a little in its developments ; in one it is broad heart-shaped, the apex posterior ; in another elongate, the sides a little concave ; in a third, more elongate and concave. The formula of triangles of both series then is: Sup. 1, $1\frac{1}{2}$. 2, $1\frac{1}{2}$. 3, $1\frac{1}{1}1$. Infer. 1, $1\frac{2}{1}1$. 2, $1\frac{1}{1}1$. 3, ?

Prof. Baird does not describe the triangles of the posterior superior molars in the *Arvicola austera* as isolated, though it might be inferred from his language. His figure, however, resembles that of the *A. pinetorum*. (See Baird, U. S. Pac. R. R. Surveys, viii, 539.)

Arvicola involuta, Cope.

Species nova.

Established on a nearly complete ramus mandibuli, with dentition perfectly preserved. It is nearly allied to the *A. pinetorum*, differing prin

cipally in the form of the anterior lower molar; (see accompanying cut). The anterior lobe of this tooth is much shortened and crescentic, the inner horn of the crescent being the apex of a ridge of the tooth. Thus there are five internal and three external ridges to the tooth. Triangles of inferior series (1) $1\frac{2}{1}1$ three lobed; (2) $1\frac{1}{1}1$; (3) 1, 1, 1. The anterior loop of the second molar is contracted, outlining two triangles. the lobes of the third are angular sub-crescentic, the anterior trapezoid. This molar differs distinctly in structure from that of the next species, q. v. The *A. involuta* is nearer the *A. pinetorum*, and is of the same size.

Arvicola sigmodus, Cope.

Species nova.

This species belongs to the same group (as characterized by dentition), as the last two, and is of about the same size, viz: about that of our common *A. riparia*. It is represented by three imperfect mandibular rami, two with dentition complete, the other with the posterior molar only wanting. Its characters are near those of *A. austera*, Lec., as pointed out by Prof. Baird. It differs from the *A. didelta* and *A. involuta* of the present paper, in the five lobed anterior loops of the first inferior molar. The loop has, therefore, besides the two basal unenclosed triangles, a smaller projecting angle on each side, and the terminal slightly angulated lobe. In the most typical specimen, the median angles of this lobe are as prominent (fig. a) as the basal, or the triangles, though the loop of the lobe is not angulated at the end.

There are, thus, five internal and four external ridges of the tooth. The triangles are as usual $1\frac{2}{1}1$, 5 lobed, (2) $1\frac{1}{1}1$, (3), 1, 1, 1. The anterior loop of the second is contracted as in the two preceding species. The third is quite different from that described under the head of *A. involuta*, and that figured by Baird for *A. pinetorum*. Thus, its three loops are chiefly extended inwardly, their outer angles projecting very little beyond the point of junction; they form a w or sigma-shaped grinding surface, whence the name of the species. Prof. Baird's figure of *A. austera* represents the first inferior molar of this species exactly, but is very different in form of the last, which is like that of the *A. involuta*. Should however, the character as here described in this tooth of *A. sigmodus*, be found to occur in the *A. austera*, the former name will become a synonyme of the latter.

Measurements.

	M.
Length grinding surface infer. molars, (No. 1.)	0.0065
" " " 1st " " "	.003
" fang and crown " " "	.004
Width inferior incisor	.0015

The dental series of the more typical specimen, whose m. 1 is outlined in fig. a, is smaller and relatively a little narrower than the others.

The supposed superior maxillary dentition is represented by both series, that of the left side lacking the first molar, with the palatine surface and

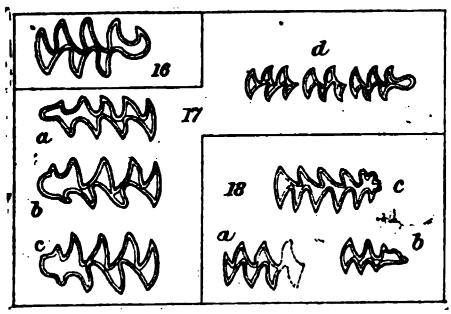
one upper incisor. The lobe formula is $1\frac{2}{2}$, $1\frac{1}{2}$, 1, $\frac{1}{1}$ 1 three lobed. The lobe of the posterior molar is quite elongate, and divaricates into two angles anteriorly, the external of which is almost isolated, almost giving the formula for the tooth $1\frac{1}{2}$ 1. The teeth of both sides are exactly alike. The near approach to isolation of this external angle is due to the deep inflection of the posterior inner groove, and very near approach to a corresponding incurvature of the lobe. This specimen is referred to the *A. sigmodus* by the analogy to the relation between superior and inferior molars seen in *A. didelta*. In the latter the terminal loop of the inferior m. 1 is more simple and the loop of superior m. 3, agrees with it in its simplicity, having nearly the same form. The increased complexity of the anterior loop of the inferior m. 1 in *A. sigmodus* is shared by the m. 3 sup. here described, though not in exactly the same manner. I refer it, therefore, to this species with a reservation.

	M.
Length of dental series	0.007
Width between middle of m. m. 2	.005
" incisor tooth in front	.0015
Length from m. 2 to incisive foramen	.0049

ARVICOLA HIATIDENS, Cope.

Species nova.

Represented by several molar teeth. These are several times as large



as the teeth occupying the same position in any of the species already mentioned in this essay, and suggest the genus Fiber. The distinctive features of the latter are the compressed oar-like tail, with rooted molars, and it is evident that the relationship of this species is not to it. Perhaps it is neither an *Avicola* nor a *Fiber*, since it differs in the structure of the teeth from the known species of both. None of the triangles are isolated, but are connected by a narrow strip of dentine, which is narrow posteriorly but widens anteriorly until it opens out into the terminal loop. Thus the sectional name *Anaptogonia* may be found ultimately applicable to a separate genus. The separation of the enamel folds merely carries to the highest degree that which is seen in the anterior part of the tooth of *A. sigmodus*.

In the inferior m. 1, the triangles which do not open on one side to the anterior loop are 1$\frac{4}{3}$, then one on each side, and the short wide terminal loop which is bilobed or emarginate in the middle of the end. The ridges, which are very prominent and acute, are, therefore, $\frac{4}{4}$; at the extremity there are two short ones, between which a third and more prominent one rises a little below the grinding surface. A little more attrition would give the distal loop a trilobate outline, and a little more, an acuminate one, from the loss of the lateral angles; finally the median ridge disappears also. In its present state one of the terminal lobes is almost external, making the ridges $\frac{4}{5}$.

Measurements.	*M.*
Length grinding surface	0.005
Width "	.0024
Length fang and crown	.0078

The accompanying cut of twice natural size explains the above remarks.

Two opposite molars held in natural relation by the matrix, resemble the above in structure and size so closely as to leave little doubt that they belong to the same species. Whether they should be referred to the superior or inferior series is uncertain, though analogy with the *Hypudæus gapperi* would suggest the latter. They represent the right and left second molars, and the triangular areas if isolated, would be 1$\frac{3}{4}$, not one of them, however, is isolated, the dentine being continuous round the entering angles of enamel. The failure of these angles to reach the enamel margin of the side towards which they are directed, and an approach to parallelism of the entering and projecting enamel plates produces a triturating surface, having the form of a succession of Ws. This is the reverse of what occurs in *Hypudæus gapperi* according to Prof. Baird, where the triangles become confluent at their bases, thus extending all across the crown; the same thing is seen in the posterior inferior molar in all the species. There is no trace of roots to these teeth or that previously described. Length of crown of second molar, m. 0056.

A third specimen is represented by the molars of both maxillary bones, much broken, the posterior of one of the series only being entire. This tooth is slightly curved, and exhibits three ridges on one side, and four on the other; triangles 1$\frac{2}{1}$ and a short loop with two basal angles, the inner more prominent than the other. None of these triangles are isolated, but are rather angular expansions of the continuous dentine. The two inner angles are much more prominent than the outer, but in old age they would probably be equal, judging from their appearance at the base of the tooth. Viewed from below, they appear to be closed, showing that the character of the group *Anaptogonia* in this respect is derived from a "retardation" of growth in a point which is early attained in true *Arvicola*.

	M.
Length of tooth	0.005
" crown	0.003
Width palate	0.004

ERETHIZON, Cuv.

The remains of a porcupine of the existing North American genus occur in the deposit. It is evidently different from the recent *E. dorsatum* and presents the following characters.

ERITHIZON CLOACINUM, Cope.

Species nova.

Represented by a last superior molar of the left side, and a portion of one of the inferior incisors. The former indicates the distinctness of the species by two peculiarities. One of these is the greater vertical depth of the external inflection of enamel. It is nearly as deep as the internal, while in *E. dorsatum* it is very much shallower, the internal extending down to the alveolar border. This appearance in the present species is not due to deficient attrition, for the molar in question is well worn, so as to leave the margins of the anterior island well posterior to the anterior enamel margins of the tooth. This anterior island is a transverse oval, slightly concave behind.

The general form of this tooth is T shaped, with an expanded triangular base. The second specific character is seen here ; for while the recent species posesses an enamel island or annulus which occupies this space entirely, the *E. cloacinum* exhibits two, the additional one being on the inner side and smaller than the usual one. It is suboval, and occupies the inner posterior angle of the triturating surface, which is expanded, and less than a right angle. I find no trace of this in five crania which I had the opportunity of examining.* The sizes of both this tooth and the incisor are about equal to the largest seen in the *E. dorsatum*. The enamel of the latter is not smooth, and has a minute interrupted striation.

Antero-posterior diameter of crown of molar m. 0076 ; transverse do. m. 0077 ; width anterior face of incisor m. 0055.

LEPUS, Linn.

LEPUS SYLVATICUS, Bachm.

Portions of crania of six individuals not distinguishable from this recent species. The palatal surface of one is exposed, and is longer in relation to its width than in a recent example. Thus in the former the length enters the width between the two anterior alveoli 1.2 times; in the latter 1.6 times. In Prof. Baird's figure it enters 1.4 times. Some of the specimens are smaller, some larger than the average of our recent ones. One of them had an oval mass of carbonaceous matter in its mouth, probably the remains of its unswallowed vegetable food.

PRAOTHERIUM, Cope.

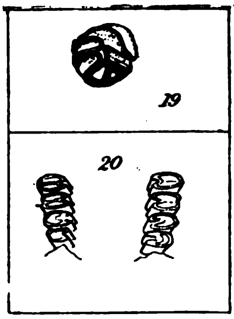
Molars similar to those of *Lepus*, rootless, with oval crowns transverse to the axis of the series, all simple ; masticatory surface not divided by median ridge, enamel boundary emarginate on the inner side. Number in maxillary bone? four.

* I owe a skeleton of the *E. dorsatum* from Muncy, Penna., to the kindness of my friend, Jas. S. Lippincott.

PRAOTHERIUM PALATINUM, Cope.

Species nova.

This rodent is represented by the palatal region of the cranium of one individual, with four superior molar teeth of each side in position. The latter diverge symmetrically, probably in consequence of pressure. But a



small part of the palatine surface is preserved. The normal number of teeth is uncertain, but the anterior tooth is known from its relation to the fragments of maxillary bone and perhaps zygomatic arch. It resembles the three molars which follow it. Behind the fourth no trace of tooth or bone could be found on exploring the matrix, though the latter was unbroken, hence it is possible, though not certain, that there were none.

The genus differs from those of the *Geomyinae* of Baird, in the simplicity of the first molar. The wide palate and narrower zygoma, as well as the forms of the teeth, are those of the rabbits, but it differs from the two genera, *Lepus* and *Lagomys*, in the identity of structure of the first molar with the others, and the absence of an enamel band dividing the triturating surface of each of them. In some of the teeth a trace of the dividing lamina is visible, but does not appear to have been elevated into a crest of the grinding surfaces.

In specific characters, this rodent differs from our rabbits in its small size, and in having the molars deeply longitudinally grooved on the inner face, instead of the outer. In worn teeth this groove is continued into the grinding surface of the crown, without interruption from the enclosing enamel. The form of this surface is then an oval, notched on the inner side, and rounded or slightly truncated on the outer. The palatine face is but partially preserved, and is considerably wider in proportion to the diameter of the teeth than in *Lepus sylvaticus*.

	M.
Length crown of four consecutive molars	0.0061
Width " one molar	.0021
" palate between bases of molars	.0100

SCALOPS, Cuv.

The only remain certainly referable to this genus is a humerus. As the

form of this element is very characteristic among the Talpidæ, the species may be determined from it with considerable precision. Its form is less stout than in *Talpa europæa* and *Scalops aquaticus*, but considerably more so than in *Condylura cristata*. In the uncertainty as to whether it can belong to *Scalops breweri*, I leave it without a name.

?VESPERTILIO, Linn.

Numerous slender bones referable to this or an allied genus, are found in the cave deposit.

MASTODON, Cuv.

MASTODON AMERICANUS, Cuv.

Numerous fragments of teeth, cranium, vertebræ, and extremities, of a large individual, with tusks measuring five to six inches in diameter. Some three-crested, and several primary or two-crested molars, indicate a second, smaller animal.

TAPIRUS, Briss.

TAPIRUS AMERICANUS, Auct.

Numerous teeth from all positions in both jaws indicate several individuals of different sizes. Some of them are of the size of the existing species of South America, and do not exhibit any differences of specific importance.

TAPIRUS HAYSII, Leidy.

Holmes' Postplioc. Foss. S. Ca., Pl. xvii. figs. 4, 5, 7, 8.

Four superior and six inferior molars do not differ in any respect from those of the preceding species. excepting in size. In this they exceed the latter, having about twice the superficial area. Leidy appears to have proposed this species on account of size only, and the specimens may indicate a valid species. Two superior molars, perhaps referable to the *T. americanus*, differ less in size, exceeding a little those of our recent specimens.

Dimensions of three superior molars of the largest (*T. haysii*), medium and smallest (*T. americanus*) size are given. The last two are worn, the first had not protruded through the gum.

	M.
Length, 1	0.029
Width, 1 (greatest)	.0332
Length, 2	.023
Width, 2 (greatest)	.029
Length, 3	.0218
Width, 3 (greatest)	.025

In addition to the teeth, there are numerous bones of the extremities, tarsus, &c., and vertebræ.

EQUUS, Linn.

Numerous phalanges of two species of slender proportions and smaller size than the recent domesticated horse. Neither the species nor genus are determinable as yet, from the remains.

Bos, Linn.

Extremity of a femur, several patellæ and fragments of metatarsals of a large species of ox or bison are preserved with the others. The species is not yet determined.

There are, perhaps, two other species of ungulate animals not as yet determined.

Ursus, L.

Ursus pristinus, Leidy.

Arctodus pristinus, Leidy. Proc. Acad. Nat. Sci., Philada., 1854, 90, Holmes' Postpliocene Fossils S. Carolina, 1860, 115, Pl. xxiii, f. 3–4.

This bear has been known hitherto by a molar of the lower jaw found by Prof. Holmes near Charleston, S. Ca., and the references above indicate descriptions and figures of this tooth alone. Mr. Wheatley's collection contains the first and second molars in a portion of the right ramus of the mandible, and the canine and first, second and third molars of the left ramus separated from it. There are also vertebræ of bears from the cervical and dorsal regions, which are appropriate as to size, and were found at near the same time as the teeth.

A character which at once distinguishes this bear from all those now living in the northern hemisphere (faunally speaking), and those known to have inhabited it during the postpliocene period, is seen in the first molar. Instead of the usual two series of tubercles, it has on its anterior half a single rather obtuse crest, above the outer side of the crown. The crest commences with the apex of an elevated conical tubercle, which marks a point three-fifths the length of the tooth from its posterior extremity. Two very small worn tubercles are seen behind it on each side, in the specimen, while the greater part of the surface of the crown is nearly plane, and covered by unbroken enamel. It is a little depressed, and compressed from the outer side at the posterior third. The enamel of the inner side of the crown is smooth, of the outer side obsoletely rugose. The second inferior molar is about as long as the first, but wider, and of different character. The triturating surface is parallelogrammic rounded at the ends, and narrowed at the anterior third, and contracted, as compared with the width of the base of the crown. The enamel, though worn, is nowhere worn through, and its surface is remarkable for the almost absence of tubercles. The grinding surface is concave transversely, and is bounded by elevated margins. The inner and outer display each three obtuse elevations, the latter the better defined, the anterior the most elevated and connected by a low cross ridge, which is depressed in the centre. The inner sides of the crown is swollen at the base, and more oblique than the outer; both are marked with obsolete ridges, which descend from the grinding face, those of the outer most distinct. The last inferior molar is two-thirds the length of the penultimate. The form is oval, broad anteriorly, narrow posteriorly. The crown is low and flat, without tubercles, the margin a little elevated, and interiorly and posteriorly mammillated; it has a single compressed root.

The inferior canine is represented by a crown. It is remarkably short, and stout at the base; the posterior outline very concave. The usual obtuse keel is seen on its anterior inner aspect, and worn surface postero-exteriorly. The apex of the crown is worn by use. The smaller premolars have not been recovered, but the last or sectorial has left its impression in front of the first molar in place in the matrix, and appears to have been of the proportions seen in the grizzly bear.

	M.
Length three inferior molars and fourth premolar together	0.096
do M. I crown	.029
Width do anteriorly	.013
Length M. II	.031
Width do anteriorly	.0202
Length M. III	.0233
Width anteriorly	.0188
" posteriorly	.0135
Length crown and root	.035

In size this species probably equalled the grizzly bear, as the teeth are as large as those of any of the numerous crania in the Museum of the Academy Natural Sciences, though Prof. Baird gives measurements of some in the Smithsonian collections, which are larger. Should the teeth be related to the skeleton as in our black bear *U. americanus*, a still larger size is indicated. The nearest relationship in the characters of dentition is to be seen in the *U. bonaerensis*, of Gervais* of Buenos Ayres. It has the peculiar form of the first molar seen in *U. pristinus*, but differs specifically in that of the second, which is interrupted in one of its outlines and rather more tubercular.

As compared with *Ursus amplidens*, Leidy, the following relations appear. The last molar has a smaller crown than in the type specimen of the latter. In *U. pristinus*, and the last is between .50 .75, the length of the second molar; in *U. amplidens*, exactly as in *U. horribilis*, five-sixths length of crown, or equal the extent of alveolæ. The third molar is less contracted behind in the type specimen of *U. amplidens*. The latter species appears to be in many ways nearly allied to the grizzly bear.

The discovery of this species by Mr. Wheatley, in Pennsylvania, is particularly interesting, as fixing an extended range for it, and proving that our cave bear is totally distinct from that of Europe, and rather of the type which was associated with the gigantic sloths in the southern regions of South America, at the same geologic epoch.

FELIS, Linn.

Two proximal phalanges of a species of this or an allied genus, were found by Mr. Wheatley. They pertained to an animal of the size of the jaguar, (*Felis onca*). A fragment of a canine tooth indicates a cat as large as the tiger, but is too imperfect to allow of determination. Some vertebræ of a carnivorous animal, perhaps of a dog, were also found.

*Palaeontology of Castelnau's Anim. novo. on Rar Am. Sud., Pl. fig.

The result up to the present time may be summed up as follows:

Edentata.	Species.	Individuals.
Megalonyx	5	15
Mylodon	1	?2
Rodentia.		
Arvicola	6	15
Hesperomys	1	1
Jaculus	1	1
Sciurus	1	2
Erithizon	1	1
Lepus	1	7
Praotherium	1	1
Undetermined	2	2
Insectivora.		
Scalops	1	1
Chiroptera	?1	6
Ungulata.		
Mastodon	1	2
Tapirus	2	4
Equus	2	3
Bos	1	3
Undetermined	2	3
Carnivora.		
Ursus	1	?2
Canis	?1	1
Felis	2	2
Mammalia total	34	72

Of birds there are fragments of two species, one a turkey, with the spur preserved, probably the *M. altus*, Marsh; (*M. superbus*,† Cope. Trans. A. Phil. Soc., 1870, pp. 239, ii), the other a snipe. The reptiles include one or two species of tortoises, and three or four serpents. There are a few bones apparently of Batrachians. The whole number of species of Vertebrata is about forty, represented by perhaps ninety individuals.

Dr. Geo. H. Horn, to whom Mr. Wheatley submitted the insects, reports, at an early stage of the investigation, thirteen species of *Coloptera* and two or three of other orders, including *Orthoptera*. We await with much interest the further results of this research, as the determination of Postpliocene Coleoptera has not been practicable heretofore. The names already published by Dr. Horn,* are, Carabidæ—*Cychrus wheatleyi Cychrus minor, Cymindis aurora, Chlaenius punctatissimus, Pterostichus laevigatus, Pt. longipennis, Dicaelus alutaceus ;* Scarabaeidæ, *Aphodius scutellaris, Apho. micans, Phanaeus antiquus ; Copris punctulatus ;* Histeridæ ; *Saprinus ? ebeninus.*

† As it is now fifteen months since Prof. Marsh announced his species, and no description has yet appeared, it appears to me that *M. superbus*, the only name accompanying a description, will have to be adopted, if the two are really the same.

*Am. Jour. Sci. Arts, 1871, 385, in a notice by C. M. Wheatley.

GENERAL OBSERVATIONS.

Several authors have noticed the great difference in character between the postpliocene fauna of North America, and those which preceded it, in Tertiary time. It is well known, that while the Miocene Mammalia are more or less similar to those of Miocene Europe and Asia, and the Pliocene vertebrata have a corresponding resemblance to those of the same period of Europe and Asia, and the present one of Africa, the postpliocene resembles, in many particulars, that of South America or the Neotropical region.

In examining the list of postpliocene mammalia, known up to 1867,* I found, that of 30 species, eleven were represented by members of the same genus or family, in the Neotropical region. In an enumeration of the species from the caves in 1869,† which included 27 species of 23 genera, six genera were shown to be of neotropical type. In an unpublished list of vertebrata, which the writer exhumed in a bone breccia, from a cave in East Tennessee, there are twenty species included. Prominent among these, are *Megalonyx*, *Dicotyles*, *Tapirus*, *Cervus*, and *Sciurus*, the first three neotropical. The species from the Port Kennedy bone cave may be arranged as follows:

	Species.
Neotropical forms	11
Peculiar Nearctic (North America)	3
Genera common to north of both Hemispheres	11
Uncertain	9
Total	34

The theory of evolution requires that change of fauna in any very brief period of geologic time, should be accomplished by migration. Accordingly, authors have suspected that Asia and North America, and perhaps Europe, were connected by land during the miocene period. Thus Leidy, (Mammalia of Dakota and Nebraska, 1869, p. 360), suspects that North America was peopled from the west, from a continent now submerged beneath the Pacific Ocean. Prof. Huxley (Anniv. Address, Lond. Geolog. Society, 1870), makes a similar proposition, but adds that there is no evidence as to whether the connection was with Europe or Asia. In describing fossil *Cobitidæ*, a family of fresh water fishes, from Idaho, in 1871, (Proceed. Am. Philo. Soc., p. 55,) I have adduced evidence that the connection was with Asia. These *Cobitidæ*, as is well known, have no existing representatives in America, and are one of the Asiatic types, characteristic of our Pliocene period. As fresh water fishes, their migration is restricted to fresh water communication. Now, as the Rocky Mountain ranges were in large part elevated prior to Pliocene time, and the water courses had their present directions, it is obvious that the migration of fresh water fishes occupying waters on the west side of those ranges, must have been to or from the west, and not the east. That these

*Proc. Acad. Nat. Sci. Phila. 1867, 156. † Proceed. Am. Phil. Soc. 1869, 178.

fishes, then, passed through fresh water connections, existing on a continent now submerged beneath the Pacific Ocean, seems probable.

The destruction of the Pliocene fauna is generally admitted to have been brought about by the rigors of the glacial climate, and the extension southward of the ice sheet and snow falls. Near the same time, connection with Asia must have been severed by the descent of the North Pacific Continent. Some Pliocene types, not now existent in North America, may have been driven into the Neotropical region, and may be still represented in their descendants, the Lamas, the only existing *Camelidæ* of the new world, with the horses and perhaps others of the higher mammalia of that region. The existence of the extinct *Mastodon*, *Machaerodus*, etc., in the postpliocene of the same region, mentioned by Huxley, as a puzzling fact, (Address l. c.) may be accounted for in the same way.

Of course, on the northward retreat of the ice sheet, the mammalia fauna would have to be derived from the south, for communication direct with Asia no longer existed. If Behrings straits were not yet opened, the masses of glacial ice covering those regions would effectually prevent immigration by that supposed connection. The resulting Postpliocene fauna would naturally partake of the mixed character which our brief investigations into it have revealed. The neotropical forms would occupy regions left vacant, or peopled by a sparse remnant of boreal genera and species. This view I proposed some time ago,* and Dr. Leidy has added his valuable opinion to the same effect.†

Has any great disturbance of level intervened between the occupation of the post-pliocene fauna and the present period? Prof. Dana (Manual of Geology, 1862,) summarizes the results attained up to his writing (p. 553), by showing that the period succeeding the glacial drift was one of submergence, especially in arctic latitudes. He states the depression near Montreal to have been 450 or more feet, and 1000 feet in Arctic regions. Of the Middle States he says nothing, and of the south, that the evidence is not satisfactory. This descent of level he regards as that which caused the melting of the glacial ice, stratification of the drift, deposition of gravels, and elevation of temperature. All these changes would naturally precede the introduction of a postglacial fauna from a warmer region, so that for this and other reasons, the Champlain epoch may be regarded as that opening the post-pliocene, and its fauna to be represented by the Walrus, which extended its range to Virginia, the Reindeer to New Jersey, and the *Beluga* of the Champlain clays.

The origin of the caves which so abound in the limestones of the Allegheny and Mississippi valley regions, is a subject of much interest. Their galleries measure many thousands of miles, and their number is legion. The writer has examined twenty-five, in more or less detail, in Virginia and Tennessee, and can add his testimony to the belief that they have been formed by currents of running water. They generally extend in a direc-

*Proceed. Acad. Nat. Sci. 1867, 156. †Mammalia Dakota and Nebraska, 359, 1869.

tion parallel to the strike of the strata, and have their greatest diameter in the direction of the dip. Their depth is determined in some measure by the softness of the stratum, whose removal has given them existence, but in thinly stratified or soft material, the roofs or large masses of rock fall in, which interrupt the passage below. Caves, however, exist when the strata are horizontal. Their course is changed by joints or faults, into which the excavating waters have found their way.

That these caves were formed prior to the postpliocene fauna is evident from the fact that they contain its remains. That they were not in existence prior to the drift is probable, from the fact that they contain no remains of life of any earlier period so far as known, though in only two cases, in Virginia and Pennsylvania, have they been examined to the bottom. No agency is at hand to account for their excavation, comparable in potency and efficiency to the floods supposed to have marked the close of the glacial period, and which Prof. Dana ascribes to the Champlain epoch. An extraordinary number of rapidly flowing waters must have operated over a great part of the Southern States, some of them at an elevation of 1500 feet and over, (perhaps 2000) above the present level of the sea. A cave in the Gap Mountain, on the Kanawha river, which I explored for three miles, has at least that elevation.

That a territory experiencing such conditions was suitable for the occupation of such a fauna, as the deposits contained in these caves reveal, is not probable. The material in which the bones occur in the south is an impure limestone, being mixed with and colored by the red soil which covers the surface of the ground. It is rather soft, but hardens on exposure to the air.

The question then remains so far unanswered as to whether a submergence occurred subsequent to the development of the postpliocene mammalian fauna. That some important change took place is rendered probable by the fact, that nearly all the neotropical types of the animals have been banished from our territory, and the greater part of the species of all types have become extinct. Two facts have come under my observation which indicate a subsequent submergence. A series of caves or portions of a single cave once existing on the S. E. side of a range of low hills among the Allegheny mountains in Wythe Co., Virginia, was found to have been removed by denudation, fragments of the bottom deposit only remaining in fissures and concavities, separated by various intervals from each other. These fragments yielded the remains of twenty species of postpliocene mammalia.* This denudation can be ascribed to local causes, following a subsidence of uncertain extent. In a cave examined in Tennessee the ossiferous deposit was in part attached to the *roof* of the chamber. Identical fossils were taken from the floor. This might, however, be accounted for on local grounds. The islands of the eastern part of the West Indies appear to have been separated by submergence of larger areas, at the close of the period during which they were inhabited by postpliocene mammalia and shells. The caves of

* See Proceed. Amer. Phil. Soc. 1869, 171

Anguilla include remains of twelve vertebrates,* of which seven are mammalia of extinct species, and several of them are of large size. These are associated with the recent species of molluscs *Turbo pica* and a *Tudora*, near *pupæformis*.† As these large animals no doubt required a more extended territory for their support than that represented by the small island Anguilla, there is every probability that the separation of these islands took place at a late period of time and probably subsequent to the spread of the postpliocene fauna over North America.

EXPLANATION OF THE CUTS.

Figs. 1–12. Sections of teeth of *Megalonyx* of the natural size.

Fig. 1–2. Sections of canine-molars of *M. loxodon*, Cope; 2a, profile of 2 from within.

Figs. 3–6. Sections of canine-molars of *Megalonyx wheatleyi*, Cope; 5a side view of 5 from the inner side.

Figs. 7–8. Sections of canine-molars of ? *Megalonyx dissimilis*, Leidy, or of *M. wheatleyi*, Cope.

Fig. 9. Sections of crowns of the superior molars of the right side of *Megalonyx wheatleyi*; from separated teeth, the anterior probably of this species.

Fig. 10. Sections of crowns of the inferior molars of the right side of *M. wheatleyi*, from specimens in place in jaw.

Fig. 11. Crown of tooth of *Megalonyx sphenodon*, Cope; 11a, same from the inside.

Fig. 12. View of canine-molar of *Megalonyx tortulus* seen from the crown; 12a, inner view of same tooth.

Fig. 13. Grinding surfaces of left inferior molars of *Arvicola speothen*, Cope, enlarged.

Fig 14. Grinding surfaces of second and third superior molars of *Arvicola tetradelta*, Cope.

Fig. 15. Same of *Arvicola didelta*, Cope, enlarged; a, b, c, of the first inferior molar; d, of the superior molars.

Fig. 16. First inferior molar grinding surface of *Arvicola involuta*, Cope, enlarged.

Fig. 17. Same of *Arvicola sigmodus*, Cope, enlarged; a, b, c, of first inferior molar; d, of superior molars.

Fig. 18. Same of *Arvicola hiatidens*, Cope, enlarged; a superior molar 1 or 2, incomplete; b, 3d superior molar; c, 1st inferior. The entering folds should not be in contact in figs. *a* and *b*, in cuts.

Fig. 19. Grinding surface of last superior molar of *Erithizon cloacinum*, Cope, natural size.

Fig. 20. Superior molar teeth (incomplete) of *Praotherium palatinum*, Cope, natural size.

* Loc. cit. 1869. 183; 1870, 608. A fourth species of gigantic Chinchillid has been found by Dr. Rijgersma, which may be called *Loxomylus quadrans*, Cope. It is represented by portions of jaws and teeth of three individuals. It is one of the largest species, equalling the *L. latidens*, and has several marked characters. Thus the roots of the molars are very short, and the triturating surface oblique to the shaft. The roots of the second and fourth are longer than those of the first and third. The last molar has four dental columns instead of three as in the other *Loxomyli*, and is triangular or quadrant-shaped in section; the third is quadrangular in section, and has three columns. The second is the smallest, being only .6 the length of the subtriangular, first. Length of dental series m. .063 or 2.5 inches. Palate narrow and deeply concave. There is but little or no lateral constriction in the outlines of the teeth; the shanks are entirely straight. In its additional dentinal column, this species approaches the genus *Amblyrhiza*.

The large Chinchillas of Anguilla are as follows, *Loxomylus longidens*, *L. latidens*, *L. quadrans* and *Amblyrhiza inundata*.

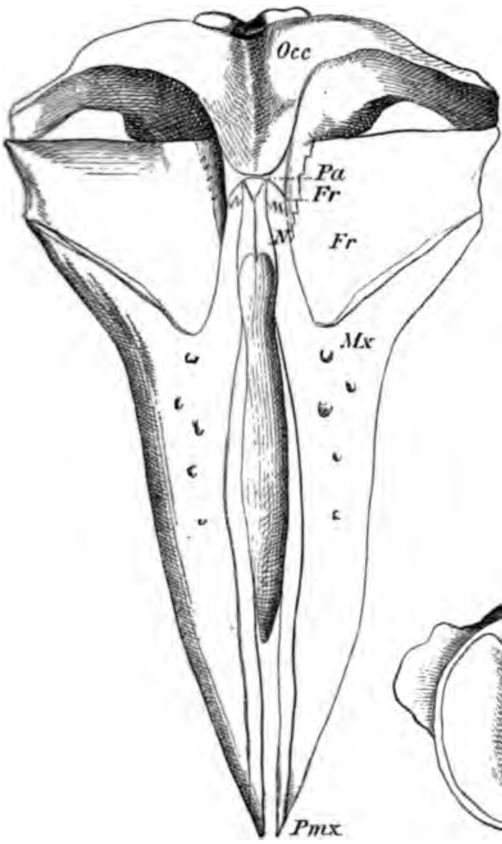
† See Bland, Proceed. Amer. Phil. Soc., 1871, 58.

ON MEGAPTERA BELLICOSA.

By E. D. Cope, A. M.

(*Read October* 21, 1870, *before the American Philosophical Society.*)

For many years American Whalers have been in the habit of taking hump-back whales off the coast of San Domingo, and in other parts of the Caribbean Sea. Desiring to determine the species which is the object of their pursuit, and which, no doubt, haunts the Floridan and



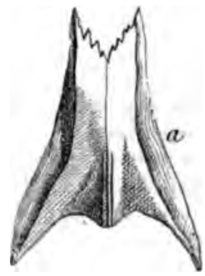


Fig. 22.

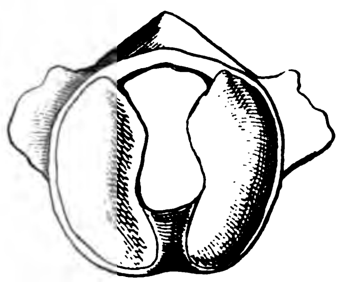


Fig. 21. Fig. 26.

other southern coasts of the United States, I wrote to my friend, Dr. A. Goës, colonial physician at St. Bartholomew's, W. I., in reference to the possibility of procuring a skeleton of it. His efforts, undertaken in pursuance of this object, resulted in the preservation of the skeleton of an individual of thirty-two feet in length, which he forwarded to Philadelphia, and which has furnished the following characteristics.

The skeleton lacks a few pieces, viz.: the sternum, pelvic bones, and perhaps four caudal vertebræ. Of the latter, one is a large anterior vertebra, two are median, and one between the latter and the distal. The whole number thus restored will be, Cerv. 7, D. 14, L. 10, Caud. 20; total 51. The lengths of the cranium and these elements are:

	Ft.	In.
Cranium	9	
Caudal vertebræ	8	10
Remainder of vertebræ	13	6
	—	—
Total	31	4

The *cranium* is not very different in some respects from that of the *M. longimana* of the North. The supraoccipital bone has a deep but open median groove from the foramen magnum to near the horizontal superior surface, where it is wanting. On each side of it there is a considerable protuberance near the middle of the height of that bone.

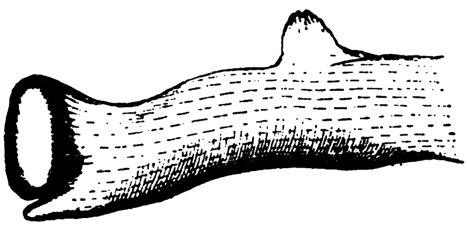


Fig. 23.

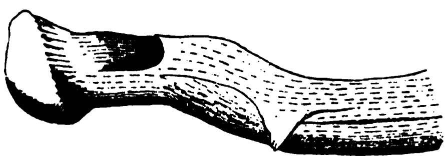


Fig. 24.

The orbital plates of the frontal are plane, with straight anterior and posterior margins. The posterior extremities of the premaxillaries are laminar; their middle portions are separated by a considerable vacuity. The maxillaries are not slender, and are plane; they present several large foramina near their middle. The nasal bones present marked characters. Their median face of common contact extends throughout much of their length, and the posterior divergent portion is very short (see fig. 22), and serrate for suture. A beveled portion of the external face (fig. 22a) is concealed by the maxillaries; the remaining portion is narrow. The median projection of the bones is less than the lateral, and is carried on a keel above the level of the lateral portion of the bone, as

in *Sibbaldius tectirostris*, Cope. The whole form is very different from that of the *M. longimana*. The depth and length of the bone on the interior (median) face, are about equal. The otic bulla is subcylindric, a little flattened on the inner side; its surface is quite smooth.

The ramus of the mandible is slender, and when viewed from above, considerably curved. It has an elevated subtriangular and acuminate coronoid process, quite as in a Balænoptera. (Fig. 24 from above.) Proximally the ramus has a slight sigmoid curve viewed from the side (fig. 23), and in the general is more slender than that of *M. longimana*, in profile. The angular process is prominent; the shaft is plane on the inner side, on the external very convex; it is nowhere compressed, and the external pores are widely separated.

Fig. 25.

The atlas has no neural spine and no *tuberculum atlantis*. The diapophyses are compressed, irregularly truncate, their inferior margin considerably above the fundus of the *foramen dentati*. The axis presents a rudimental odontoid process. Its diapophysis and parapophysis are not very stout, and the former is the longer. The parapophyses diminish rapidly till the fifth vertebra presents only a rudiment on one side. The articular faces of these cervicals are a transverse ovate. The diapophyses are slender and straight. (See figs. 26 atlas, 27 axis, and 28, third cervical.)

Fig. 27

Fig. 28.

Two of the diaphophyses of the caudal vertebræ are hooked in form, owing to the failure to isolate anteriorly the foramen which pierces them. The scapula is without rudiment of coracoid and is longer than deep; its proportions are similar to those of *M. osphyia*.

The fore limbs are neither of them quite complete. The epiphysis of the humerus is still free, and indicates that the animal was young when captured. The bones of the forearm are much as figured by Rudolphi

in the *M. longimana;* the radius stout, expanded at the ends, the ulna shorter, more slender, curved and with an olecranon. The metacarpi, or the first series, are quite elongate, except that of the upper (inner) digit, which is stouter. If there were six digits in the second digit (third), the limb measured 8 feet 4 inches, but if, as in *M. longimana*, there were eight, it equalled the cranium in length (9 feet).

Measurements.	*ft.*	*in.*
Total length of skull, (axial)	9	
Length of maxillary to emargination for frontal plate	5	5
" transverse, (to axis of skull) of orbital frontal plate	2	5
" longitudinal " " "	2	2
Distal width over orbit " " "		11.5
Length nasal bone		9
Width " "		1 5
Width cranium behind orbits, (greatest)	5	4
" muzzle half way to frontal plates	2	3.5
" maxillary $\frac{3}{4}$ way " "		10.5
Length mandibular ramus on curve	9	10
First rib, length on curve		37
" " distal width		7
Humerus length	1	9
Radius "	2	6
Scapula height		25.5
" width		39.5
" glenoid cavity length		11.5
" " " width		9

The simple headed first rib indicates the generic relationships to be with Megaptera, as does the entirely simple scapula.

In reply to my enquiries, Dr. Goës gives the following account of the external appearance of this whale. The dorsal outline is strongly convex, and it is questionable whether a dorsal fin exists, as he had not seen it on two specimens from the decks of the vessels to which they were fastened. The color is sooty black above, the breast, belly, and under sides of pectoral fins milk white, marked with scattered black spots or dots.

The condition of the specimen allows of an exact comparison with the species of this genus already known from the Atlantic Ocean. The skeletons of the two Pacific species, are unfortunately unknown, so that comparison with them cannot be made.

From *M. lalandii* of the Cape seas, it may be at once distinguished by its lack of acromion process on the scapula. Cuvier, who figures the Cape species,* does not indicate the deep occipital groove, but rather a keel without lateral protuberances, a difference too marked to be dependent on age; his orbital plates of the frontal are considerably narrower, and his fourth cervical bears no parapophyses. He does not figure such a prominent coronoid process. The coloration of this species is much like that of the West Indian whales.

*Ossemens Fossiles, 227-1.

Many marked differences separate it from the Kreporkak, of the northern Atlantic and Arctic Oceans. The elevated coronoid process and peculiar nasal bones distinguish it at once. Thus in *B. longimana* these elements are shorter and wider, considerably separated behind, and with the median process which overhangs the nares, considerably longer than the lateral. The reverse is the case here (fig. 2). The head bears a greater proportion to the length of the body than in *B. longimana*. Thus Flower notes a specimen in mus. Louvain (Belgium), of 32 feet 2 in. in length, of which the head measures only 8 ft. 6 in. In the present of 31.6 in., the cranium is 9 ft. In a specimen at Brussels of 46 ft., the head is 12 ft., nearly one fourth. In a young specimen of 28 ft. 7 in., at Leyden, Flower says the cranium measures only 7 ft. 7 in. In a specimen from the Dee, England, the proportions are similiar. As the length of the flippers is similar to that of the head, the difference is to be seen in this also. Other characters which distinguish the species from *B. longimana*, are the less concavity of the orbital plates of the frontal anteriorly, and the reduction of the lumbosacrals to 10. If Rudolph's figures be correct, the first rib is broader in the present animal, but the figure may be inaccurate. As to color, the pectoral fin is entirely white in the Arctic *Megaptera;* black externally in this one.

The same differences are to be observed in comparing with the *M. osphyia*, in which the head and fin are even shorter than in *M. longimana*, (the proportion being 9.40*) and the coronoid process equally rudimentary. Special features of the latter are seen in the flat, deep diapophyses of atlas, which are much deeper than in the present whale ; and the articular area on the hinder angle of the first and other ribs, which is wanting here. The width of the orbital plates distally is, .5 their length in the type of M. osphyia, .83 the length in the present specimen.

The species described by Gray (Catal. B. Mus., 1866, 162,) as *Physalus brasiliensis*, founded on some baleen of the "Bahia finner," has been supposed by me (Proc. A. M. Scie. Phila., 1867, p. 32,) to be a Megaptera. Certain it is that a Megaptera is found at Bahia, as I have seen larger and smaller portions of two skeletons of one, but whether it be the "Bahia Finner" and *P. brasiliensis*, Gray, is quite doubtful. In the first place, fishermen and whalers never call a "hump-back" (Megaptera) a "finner ;" if they have done so in the case of this species, it evidently has a noticeable dorsal fin, which is wanting in the present whale. In the next place, baleen of the "Bahia finner" has a commercial value, being exported to England, while that of Megaptera has none, being coarse and twisted. That of the specimen here described was thrown away by it captors.

I therefore believe that the present whale has not been noticed by naturalists, and is unknown to Zoology. I propose to call it MEGAPTERA BELLICOSA.

Dr. Goës says of its habits, that it appears about the island of St. Bartholomew in the beginning of March, or even in February, and remains

*See Proc. Ac. Nat. Sci., 1868-194.

until the end of May. In April and May it is said that they are seen in pairs, standing vertically in the water. When they return, they often come in a family of three, male, female and young, the calf of one or two years old. The bull is wild, and more difficult to take than the female, and he has, on two occasions, smashed the boat of his pursuers to pieces. In June they are said to go farther in the Mexican Gulf, and return eastward in the autumn, but they do not appear among the smaller Antilles at that time.* Dr. Goës supposes that they pass the straits of Florida, or follow the shores of the South Main. He says that the whalers think they pass the middle of wihter on the African coast, but this will require confirmation.

Additional note on BALAENOPTERA vel SIBBALDIUS SULFUREUS, Cope.

This species was first brought to the notice of zoologists by Captain C. M. Scammon, in an extended paper on the Cetacea of the Pacific Coast of North America.* From the data furnished by him, the writer was enabled to determine it as distinct from any of the species hitherto known, under the above name, with the following characters :†

Dorsal fin small, conic, situated on the posterior fourth of the back. Form slender ; length seventy to ninety feet. Color, above, grey or brown ; below, sulphur yellow.

Capt. Scammon having sent to the museum of the Smithsonian Institution four laminæ of whalebone, I am enabled to add important points to the above diagnosis, as follows :

Baleen black everywhere. Bristles intermediate in size, between those of Sibbaldius tectirostris, Cope, (finer) and Megaptera osphyia (coarser), in six or eight rows, and seven or eight inches in length. Length of plate, without bristles, two ft. eight inches ; width of base eighteen inches. Laminæ with weak transverse rugosities.

The above characters show conclusively that this whale is different from the *B. antarctica*, Gray, which is also called sulphur-bottom by the whalers in the South Pacific. The whalebone of the latter is yellowish white.

EXPLANATION OF CUTS.

Fig. 21—Cranium of *Megaptera bellicosa* from above.

Fig. 22—Nasal bones from above.

Fig. 23—Posterior portion of ramus mandibuli, from outside.

Fig. 24—Same as 23 from above.

Fig. 25—Basihyal bone from above.

Fig. 26—Atlas from front.

Figs. 27 and 27—Portions of articular faces and processes of atlas and third cervical vertebræ.

*Proceed. Acad. Nat. Sci., Phila., 1869, p. 51.

† Loc. cit., p. 20.

Stated Meeting, April 7th, 1871.

Mr. FRALEY, Vice-President, in the Chair.

Present, twelve members.

Donations to the Library were received from the Academies at Berlin and Leyden, the Royal Society at London, and the Editors of Nature, the Old and New, and Penn Monthly, the New Bedford Public Library, Medical Journal, Franklin Institute, College of Pharmacy, Academy of Natural Science at Philadelphia, the Engineer Bureau at Washington, Essex Institute, Wisconsin Historical Society, and from Prof. Mayer, of Bethlehem.

Prof. Cresson laid before the Society a map of Fairmount Park, reduced by photolithography to a very small size, yet exhibiting every line clearly.

Prof. Cope described additional new genera and species from the Port Kennedy Cavern, nearly one half of which were of South American types.

Mr. Chase read a communication on "The Resemblance of Atmospheric, Magnetic and Oceanic Currents."

Lieut. Dutton explained his views of the origin of Regional Subsidence and Elevation.

The curators were requested to provide for the proper preservation of the Photographs of Lines of Magnetic Force, presented to the Society by Prof. Mayer.

Pending nominations were read and the meeting was adjourned.

Stated Meeting, April 21st, 1871.

PROF. CRESSON, Vice-President, in the Chair.

Present, eleven members.

A Photograph for the Album was received from Prof. Alexander Braun, of Berlin.

Letters acknowledging the receipt of the Society's recent publications were received from the Institute at Halifax, (entire series of Proceedings No. 1-84), New York Lyceum (85); Royal Society of Edinburgh, 78, 79-81, and Trans. (XIII. 3); and the Royal Saxon Society (XIII. 3).

Letters of Envoy were received from the Society at Görlitz, and the Editors of Old and New.

Donations for the library were received from Dr. Braun, of Berlin, the Upper Lausatian Society, the Anthropological Society and Geological Institute at Vienna, the Italian Geological Committee, M. Seguin ainé of Paris, the Linnean, Chemical, Asiatic and Antiquarian Societies in London, the Editors of Nature, the Royal Society at Edinburgh, the Philosophical Society at Glasgow, the Institute of Sciences at Halifax, the Peabody Academy at Salem, Silliman's Journal, Prof. Hall of Albany, the Young Men's Association at Buffalo, Mr. H. C. Bolton of New York, the New Jersey State Geologist, the New Jersey Historical Society, the Franklin Institute, and the chief of the U. S. corps of Topographical Engineers.

The death of Wm. Haidinger of Vienna, on the 19th ultimo, was announced with appropriate remarks by Dr. Genth.

The death of Edward Lartèt, in the department of Gers, during the late German investment of Paris, was announced by the Secretary. Mr. Cope added his personal testimony to the value of the Palæontological labors of the deceased.

Prof. Cope offered for publication in the Proceedings, a Preliminary Report on the Vertebrata discovered in the Port Kennedy Cave.

Dr. Genth described some striking results of recent analysis of Pseudomorph Corundums, and promised a fuller account of them when his investigations were further advanced.

Prof. Cresson desired a memorandum to be made of the appearance of the tender shoots of the swamp cabbage, blue bell and other wild flowers, under remarkable circumstances of difficulty, in a part of Belmont Glen, in the Philadelphia Park, where an artificial asphalt road had been laid directly upon the sod. The road was two inches thick, perfectly solid, and in use by vehicles. Yet this rigid and heavy covering has been lifted and broken in many places by the young plants, which present themselves in a living, although damaged condition to the air and light.

The Secretary described a new discovery which he had just made in East Tennessee, of a sharp anticlinal axis, crossing the coal measures of the Cumberland mountains, at right angles to the dominant system of disturbances, and showed its important bearings on the question of the conversion of the northern anticlinals into the southern downthrows, as well as its relationship to the latter; and to the cross undulations worked out by Mr. Joseph Lesley, in his instrumental survey of the East Kentucky coal measures, twelve or thirteen years ago; and also to the N. W., S. E. system of faults described by Owen, Hall and other Geologists, in the valley of the Mississippi.

Mr. Briggs described certain movements observed under the microscope in matter mechanically suspended in a fluid and vulgarly supposed to indicate vital force, a view from which he dissented, referring to Baron Rumford's recorded observations of the same phenomenon. Mr. Briggs took occasion to exhibit for the inspection of the members, the Watt medal which he had received from the Society of Civil Engineers in London.

Pending Nominations Nos. 669 to 674 were read, and balloted for, after which the presiding Officer pronounced the

following named gentlemen duly elected members of the Society:

Gen. Herman Haupt, of Philadelphia.

Prof. E. B. Andrews, of Marietta, Ohio.

Rev. F. A. P. Barnard, D. D., LL. D., President of Columbia College, N. Y.

Rev. T. D. Woolsey, D. D., President of Yale College, New Haven, Connecticut.

Rev. James McCosh, D. D., President of Princeton College, New Jersey.

Prof. Charles W. Eliot, President of Harvard College, Cambridge, Massachusetts.

And the Society was adjourned.

Stated Meeting, May 5, 1871.

PROF. CRESSON, Vice-President, in the Chair.

Present, fourteen members.

A letter accepting membership was received from Charles W. Eliot, dated Cambridge, May 1, 1871.

A letter acknowledging receipt of Trans. A. P. S. XIV. I. was received from the Secretary of the Smithsonian Institution.

Donations for the Library were received from the R. Prussian Academy, R. Astronomical Society, Sir Charles Lyell, Editors of Nature, Old and New, Penn Monthly and Canadian Naturalist, the Peabody Academy at Salem, Boston Natural History Society, Massachussetts Historical Society, New York Lyceum, College of Pharmacy, Baltimore Public School Commissioners, Hon. Charles Sumner, Dr. Hayden, P. B. Dyke, and a Map of St. Domingo from Dr. Genth.

The Secretary read the description of a new and improved field transit instrument, manufactured by Messrs. Heller and Brightley of Philadelphia; and exhibited the parts of the instrument which show improvements.

The Secretary read from Mr. Jno. Fulton's report of the Mammoth Fossil Ore bed discovered in 1867, in Woodcock Valley, Blair Co., Pa., in evidence of what important discoveries may still be made in districts of the State supposed to be well known.

The Secretary offered for publication in the Proceedings, a Grammar and Vocabulary of the Mexican language, by Mr. Adolf Burck, which was referred to Dr. Brinton.

Mr. Chase exhibited two corresponding Curves; one of the annual auroral curve at New Haven; the other of the annual rain curve at Philadelphia; and described the probable cause of their agreement.

And the Meeting was adjourned.

Stated Meeting, June 16, 1871.

PROF. C. B. TREGO, in the Chair.

Present, five members.

A photograph of Mr. Joseph Saxon was presented by him self, for insertion in the Album.

A letter of envoy was received from the U. S. Naval Ob servatory.

Donations for the library were received from the Berlin Academy, London Astronomical Society, Editors of Nature, Geological Survey of Canada, Essex Institute, Boston Public Library, Massachusetts Historical Society, Editors of Old and

New, Cambridge Museum of Comparative Zoology, Mr. Edmund Quincy, Silliman's Journal, New York State Library, American Literary Bureau, Franklin Institute, Medical News, College of Pharmacy, Board of Water Works, Fairmount Park Commission, Penn Monthly, C. M. Wheatley of Phœnixville, Pennsylvania Board of Public Charities, Smithsonian Institute, U. S. N. Observatory, and Georgia Historical Society.

The Committee to whom was referred the Aztec grammar and vocabulary of Mr. Burck, reported against its publication, and the Committee was discharged from further consideration of the subject.

Mr. H. W. Field, a member of the Society, was appointed to prepare an obituary notice of the late Sir John F. W. Hershel.

Mr. Lesley communicated to the members present, certain geological facts respecting the percentage of volatile matter in the six-foot coal bed near Ursina, Somerset County, Pennsylvania, and the percentage of titanic acid in the iron ores near Greensboro, North Carolina, with a view to placing them on record.

Mr. Chase communicated a note upon the English wind-tables, and a note upon the nature of the Tidal Wave.

Mr. Cope announced that 800 species of fish had been received by him from Vienna, in good condition, being that part of Prof. Hyrtl's Osteological Collection which Prof. Cope had secured, against the competition of the British Museum, and other European Cabinets desirous of possessing it, and described the admirable character of the preparations.

Pending nominations, Nos. 677 and 678 were read.

An extract was read from a letter of M. Carlier to M. Durand, respecting the Michaux rentes.

On motion of Mr. Cope, an appropriation was made of an additional sum of $35, to cover the total expense for the illustrations of his paper on Megaptera Bellicosa, published in the proceedings, and his paper on the Fishes of the Lesser Antilles, published in the transactions.

And the meeting was adjourned.

Heller and Brightley's New Transit.

The Engineers and Surveyors' Transit as at first constructed commonly termed a "flat centre," or "Railroad Transit," although superior to the English Theodolite which it superseded, yet in practice has been found defective in the following mechanical details.

1st. The upper or vernier plate, resting and turning upon the under or graduated limb, was accompanied by so much friction, caused by the large extent of the rubbing surfaces, that in turning the vernier plate around the limb, the whole instrument would sometimes be moved upon the lower spindle.

2d. The oil that was necessarily used to lubricate the plates, would become so congealed in cold weather that the plates would not move at all, and old Railroad Engineers will readily recall the thawing out of their instruments over large fires, at every fall of the thermometer, before they could be used.

3d. The spindle upon which the entire instrument turns, being detached from the instrument, thus violating one of the standard rules, that by long experience in this country and Europe, has been found necessary in the construction of any instrument with any pretensions to accuracy, viz.: "*any instrument having a graduated plate and levels should be so constructed that both of the centres upon which the instrument turns should be always covered and not detachable from the main plates.*" To prove the utility of this rule, it is only necessary after adjusting the levels of one of this class of Transits so that they will reverse on the top centre, to clamp the two plates together, and turn the instrument on the lower spindle, and the levels will invariably be found out of adjustment, showing conclusively that through some cause, most frequently the settling of flying dust, etc., upon the surface and shoulder of the spindle, the spindle is not at right angles to the surfaces of the plates.

4th. The centre around which the graduated limb revolves can only be the thickness of the graduated limb; this centre by reason of its small surface wears after comparatively short use, and does not exactly fit the conical hole in the graduated limb, and two readings of the same object taken without any change in the position of the instrument have been found to differ by 5′, and from no other cause than this.

These various defects have caused this style of instrument to be entirely discarded in city work, and for this another construction is used in which the two main plates do not touch each other, thus obviating the two first evils, viz.: the friction of the two plates rubbing one over the other, and the stiffness of motion of the plates in cold weather. The sockets and spindles upon which the main plates revolve being long and fitting

one inside of the other, and neither of them being exposed or detached from the instrument, thus remedying the two last causes of error. These two are the only styles of Transit made, and are respectively termed the "short centre Transit" and the "long centre Transit." The "long centre," although the most perfect in its construction, has never been a favorite among Railroad Engineers for the following reasons :

1st. The increased size of the centres making it heavier, and this being a very serious objection where an instrument must be carried several miles every day as is frequent in Railroad surveys.

2d. The instrument not being detached from the tripod, except at the base, compelled the Engineer in moving the instrument from one station to another to either carry the entire instrument himself or trust it to his assistant, while in the short centre, the instrument lifting off the spindle, the Engineer could take the comparitively light instrument with all the important parts, and leave his assistant to carry the heavier portion of the tripod with its leveling screws, legs, etc.

3d. The removing and replacing of the instrument on the tripod being accomplished by means of a large screw thread, is a very tedious and unsafe method, and if not very carefully performed is liable to injure the instrument.

4th. The extra skill, time, and care required in making the long centre was so much greater than the flat centre, that the price of the instrument was materially increased.

Ever since the introduction of the Transit numerous endeavors have been made to reduce the weight of the instrument, but as they have all been conducted on the same principle, *i. e.*, reducing the thickness of the various plates, etc., their only effect was to make the instrument so slight as to be unsteady, their bearing surface so short as to soon wear loose, and the instrument always losing its adjustment. The manufacturers of this instrument have had their attention drawn to the increased strength and steadiness that the employment of the "transverse section," "ribbing or bracing," imparted to metals; and the amount of metal that could be removed from a solid plate of metal, and its strength and steadiness not impaired, but even added to, if only judicious ribbing was resorted to. In this improved Transit, which is a long centre, the weight as compared with an ordinary Transit of the same size is reduced one-half, and the instrument is not contracted in any part, but in some parts where increased size would be an advantage, such as the graduated plate, centre, etc., it has been done, but all the plates, etc., are ribbed in such a way as to be stronger than a solid plate, and all metal that did not impart either strength or steadiness has been removed.

The Railroad Engineer has in this instrument a long centre Transit that can be taken from off the tripod and replaced in a quicker and surer

way than the short centre Transit, but unlike the short centre, keeps all the centres covered and not removable from the instrument, and leaves the tripod head and legs with the four levelling screws, etc., to be carried by his assistant. The difference in weight will be appreciated by the Railroad Engineer when we inform him that a plain Transit with all its centres, etc., only weighs about as much as a Surveyor's Sight Compass, and is more steady and keeps in adjustment better than the ordinary long centre transit, weighing from 25 to 30 pounds.

The City Engineer has in this instrument all the advantages of the ordinary "long centre Transit" with only half the weight, and an increase of steadinsss.

There are several defects that are common to all Transits, among which are—

1st. The "tangent or slow motion screw" that moves the upper or vernier plate, by use becomes worn and does not fit precisely the thread in the interior of the nut through which it passes. When this occurs the tangent screw can be turned sometimes a complete revolution without moving the vernier plate. This "lost motion" or "back lash" of the tangent is one of the worst annoyances of Engineers, aud has been the source of serious errors in the field. Several methods have been devised to overcome this which we will here describe. The nut through which the screw works has been made in two sections to allow of being drawn together when the screw wears. This plan would answer if the screw always wore equally in every portion of its length, in other words was a cylinder, but this it never does, and if the nut is tightened so that the lost motion is removed from the thinner portion of the screw, it will move so tightly as to be useless when it comes to the portions that are not worn so thin. There are several methods of drawing the nut together, but they have all the same objections as the above, that is, they are not effective in the entire length, and the nut must be pressed so very hard on the screw as to make the working of the tangent very tense, especially in cold weather. Another, and the last method has been to apply a long spiral spring between the nut and the head of the screw that acts as the finger piece, thus pressing the nut and the screw from each other, and consequently removing all "lost motion" from the screw. This plan though in theory very good, in practice has been found inoperative, for the following reason: the spiral spring had of necessity to be made long enough, and stiff enough, to act in every portion of the screw's length, the alternate opening and closing of the spring by use weakened it, and in a short time it failed to remove the "back play." To get rid of this defect of "lost motion" in the tangent screw, opposing or butting screws have been sometimes substituted, but in use they do not give satisfaction, as two hands must be employed in using them, and standing from the edge of the plate, they are liable to be injured by blows, and they are apt, unless very carefully used, to throw the instrument out of level.

In this instrument we have an improved tangent screw; that no matter how much the screw may wear by use, or time, will never get "lost motion," but will instantly obey the slightest touch of the hand: this is effected by means of a long cylinder nut, from the interior of which two-thirds of the screw have been removed; into half the recess thus left in the nut, is nicely fitted a cylindrical "follower," with the same length of screw thread as the nut; this follower is fitted with a "key," that prevents it turning in the recess, but allows motion in the direction of its length. A strong spiral spring is placed in the remaining half of the recess, between the fixed nut and the movable follower, and the spring has always tension enough to force the follower and fixed thread in contrary directions, and thus to remove any "lost motion" that may occur in the screw. It will be observed, that in this method the spring always remains in a state of rest, instead of closing and opening, as has been the case in all other applications of springs, and which have been the cause of their failure. Tangent screws that have had as much as 10′ play, have been made to work entirely taut by this method.

The mode of attaching the tangent screw to the plates in this instrument is entirely new—it is a miniature modification of the "Gimbelling" of a ship's compass, and allows the tangent screw, by its free swivelling, to be tangent to the plates in every part of its length, and thus never to bind. This tangent screw is also of value for sextants, astronomical instruments, &c., where lost motion is detrimental, and a smooth, easy motion is required.

In all instruments, the brass cheeks in which the three legs of the tripod play, are fastened to the lower parallel plate by a number of small screws, commonly twelve. When the legs wear in the cheeks, and become unsteady, the only method the Engineer has of tightening the legs, is by drawing the cheeks, in which the leg moves, by means of the bolt that passes through the leg; this, of necessity, draws the cheeks out of perpendicularity, and strains the small screws that bind the cheeks to the parallel plate so much, as frequently to loosen them. This source of instrumental error hardly, if ever, occurs to the Engineer, but very good instruments have been condemned as unsteady, when an examination has shown the fault to be the above. This source of error can never occur in this instrument, as the cheeks and the parallel plate are made in one solid piece.

But to come to the last and most serious evil. The effective power of the Telescope is impaired by spherical aberration; that is, the field of view, as seen in the Telescope, is not a perfect plane or flat, but is spherical. To prove this, take an ordinary telescope, and focus it so that an object will be clearly defined at the intersection of the cross hairs or the centre of the field of view, then, by means of the tangent screw, bring the same object to the edge of the field of view and it will be found in

every case to be indistinct and not in focus; on the contrary, focus it so as to be distinct at the edge, and it will be indistinct when brought to the centre. In some telescopes, however, it is impossible to focus at the outer edge of the field, and objects will be tinged with prismatic colors, showing that these glasses are affected by chromatic aberration also; sometimes the cause of this defect lies in the object glass, but in the majority of cases, the lenses composing the eye-piece are in fault.

These aberrations affect the working of the telescope in several ways. First, it practically diminishes the size of the object glass, and the view is never so clear and distinct as it ought to be. Second, It is very difficult, and in some cases almost impossible, to adjust the eye-piece to prevent parallax, or "travelling" of the cross wires, when the eye is shifted from side to side; and practical engineers know what a sharper power of defining, and how much less trying to the eyes a "soft glass" has—that is, one that has a "flat field."

This defect has prevented the general use of the Stadia, or Micrometer wires, as a method of measuring distances without a chain, as the two horizontal hairs that are used, being in diffrent parts of the field of view, can not, in a majority of cases, be focused so as to be devoid of parallax, and the slightest travelling of the wires in this operation will give an erroneous result.

The evils of this defect were most forcibly brought to Mr. Heller and the late Wm. J. Young's notice, when one of their best Transits failed to define in tunnel work, from loss of light, from this cause, and they both endeavored, to within a short time of Mr. Young's death, to remedy it, trying all the known formulas of almost all the opticians in the country, but without any good results.

In the Telescope of this instrument these evils are entirely removed, by the employment of a new eye-piece, and advantage has been taken of the improvements that Optics have made in the last few years, in the curvatures and arrangements of the lenses that compose it; and the test referred to above, of focusing an object in the centre of the field of view, and then bringing the same object to the edge, and it still remaining in sharp focus, can be done with this telescope, and the object shows no tinge of prismatic color, showing that both chromatic and spherical aberration have been removed.

The advantages of this improved Telescope are: a clear and sharply defined field of view; a field of view so flat that the cross hairs are without parallax in every part of it, and micrometer hairs or Stadia can be used with favorable results.

The whole effective power of the object glass being used and none of the light lost, work can be commenced earlier in the morning and continued later in the afternoon than is usual. This, in the winter season, is

no slight matter to the engineer, and lastly, there is no straining of the eyes in sighting.

The spider's web, by reason of its fineness, is the only article hitherto used for cross hairs, yet in use these have been attended with some difficulties: first, the spider's web is hygrometric, or is affected by the humidity of the atmosphere—when exposed to dampness lengthening, and of course throwing the line of collimation from its true place. This defect is more serious in the Engineer's Levelling Instrument than in the Transit, instances being known where the line of collimation has altered two or three times in the course of ten hours, by reason of atmospheric changes, and of course any observations taken at those times would be defective; lastly, the spider's web being a transparent and not an opaque substance, in some positions it is impossible to see the hairs at all—this is more especially the case when sighting in the direction of the sun; that is, an easterly course in the forenoon, or westerly in the afternoon.

To remedy this defect, platina cross hairs $\frac{1}{1000}$ of an inch in thickness, or as fine as spider's web, are substituted; these being opaque, and not transparent, in sighting in the direction of the sun are still visible, and any atmospheric changes, dampness, &c., do not affect them. We believe that we are the first ones in this country who have drawn wire so thin, and the only ones who have made any practical use of Dr. Wollaston's experiment. The platina hairs are invaluable in Mining and Tunneling Instruments, that are so constantly exposed to dampness, and being opaque, no reflector to illuminate the cross wires is required.

To prevent the stiffness of working of the leveling, tangent and other screws in cold weather, which arises from the congealing of the grease that is used in lubricating them, no oil is used upon the screws of this instrument, but they are lubricated with pure plumbago.

By a simple arrangement of the clamps on the axle of our complete Transits, we make them also answer the purpose of a pair of Compass sights, for taking offsets at right angles to the telescope.

From the above, it will be seen that this instrument has the following improvements over the ordinary Transit:—1. A simple, secure and steady method of attaching and detaching from the tripod, being the only long-centre transit made that detaches as easily as a short centre. 2. An important decrease of weight, without decrease of size, and an increase of steadiness. 3. All the working parts of the tangent screw, &c., brought within the plates, making the instrument more compact. 4. An improved tangent screw, telescope, cross hairs and tripod head. 5. A pair of sights for taking offsets; and 6. A new method of lubricating the screws.

On the relation of the AURORAS TO GRAVITATING CURRENTS.

By PLINY EARLE CHASE.

(*Read before the American Philosophical Society, May 5th,* 1871.)

Prof. Loomis's observations of the number of Auroras in each month of 1869 and 1870 (Amer. Jour. of Science, 3d S., i, 309), are specially noteworthy, both because of the careful accuracy of the observer, and because they are the first published observations which furnish satisfactory data for an approximate determination of the laws of auroral distribution.

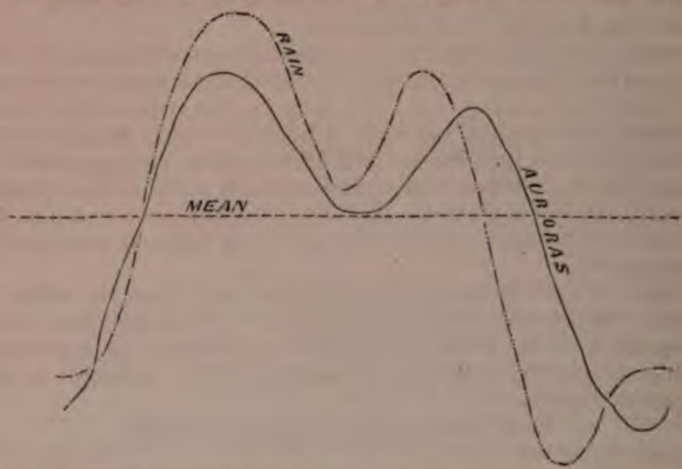
If the auroras are, as is now generally believed, luminous manifestations of terrestrial magnetism, it seems reasonable to look to them for some additional evidence upon the question of the relation between magnetic and gravitating currents. Messrs. Baxendell and Bloxam have already pointed out some resemblances between hyetal and magnetic curves, (see Proc. A. P. S., x, 368) and if analogous resemblances can be traced between hyetal and auroral curves, they will be interesting and suggestive.

I have not found the similarity between the annual distribution of rainfalls and of auroras, sufficiently striking to impress any one who has not made a special study of the causes of resemblance and difference. But, as I have repeatedly urged, currents are subject to an increased number of disguising disturbances, in proportion to the sluggishness of their motion, and the time which is consequently required for their formation or change. We may very reasonably look for analogies between the daily and the annual auroral or magnetic curves, of a character for which we could hope to find no parallel in wind, rain, or ocean-current curves.

If we desire, therefore, to find evidence of the joint influence of solar expansion and gravitating equilibrium, we should look where it is most likely to be found, and to the best of the observations which may be supposed to be fairly comparable. There are similar variations of solar attitude, and consequently increasing and diminishing solar force, in the day and in the year, but the effects of these variations upon the precipitation of vapor, are more likely to be shown in their greatest simplicity, by the means of observations at different hours of the day than at different seasons of the year. I know of no published observations of this character at New Haven, but there are some extending over a long series of years, at Philadelphia and at Greenwich, the curves at each station indicating minima of rainfall at noon and midnight, and maxima in the morning and evening. The difference of longitude between Philadelphia and New Haven being less than $2\frac{1}{2}°$, it is not likely that there is any material difference in the daily rain-curves at the two places.

In order to make the curves fairly comparable, both in regard to the times and the magnitudes of deviation, I treated the auroral observations in the same manner as those of rainfall (Proc. A. P. S., x, 526). Both in the magnetic and in the hyetal phenomena, the greatest effects accompany the greatest atmospheric changes. But in the magnetic disturb-

ances the principal maxima occur in the spring of the year and the morning of the day, while the general evaporation is increasing, whereas, in the daily rains at Philadelphia, the principal maximum occurs in the afternoon, when evaporation is diminishing. I have, therefore, compared the midwinter ordinate of the auroral with the noon ordinate of the rain curve, and the midsummer auroral with the midnight hyetal ordinate.



The auroral observations and the normal ordinates of the accompanying curves, are given in the following table. I presume no one will doubt that the condensation of vapor, which is represented by the rain curve, is occasioned by the simple operation of gravitation in blending currents of different temperatures, and I see no reason for postulating any different law for the development of electricity and magnetism in the aurora.

Comparative Table of Auroras and Rainfalls.

Mo.	No. of Auroras.	Normals.	Hours.	Normals of Rain.	Mo.	No. of Auroras.	Normals.	Hours.	Normals of Rain.
		88	0	91			100	12	103
January	32	90	1	91	July	38	101	13	106
		94	2	93			103	14	109
February	31	98	3	98	August	34	105	15	108
		103	4	105			107	16	104
March	41	107	5	110	September	43	106	17	98
		109	6	113			103	18	92
April	44	109	7	113	October	38	100	19	87
		108	8	112			95	20	85
May	36	106	9	109	November	27	91	21	87
		103	10	105			89	22	90
June	31	101	11	102	December	30	87	23	91

Winds of Europe.

By Pliny Earle Chase.

(Read before the American Philosophical Society, June 16, 1871.)

In my desire to give proper weight to considerations which favor the hypothesis of normal cyclonic currents, I stated in a recent communication to the Society (March 17, 1871), as one of the admitted facts, "that most of the European winds are cyclonic."

Further study has satisfied me that this admission is altogether too liberal, and that, although a majority of the European winds are cyclonic, the majority is not a large one. The daily weather maps of the French "Bulletin International," and the Quarterly Weather Reports of the British Meteorological Office for 1869, seem to show conclusively that in France and Great Britain, anticyclonic are nearly as frequent as cyclonic currents, and that it is only by a discussion of continuous records that the prevailing cyclonism, such as is indicated in the following table, can be demonstrated.

I have deduced the average direction of the winds from the tables in Coffin's "Winds of the Northern Hemisphere." Those marked (C) were computed by Prof. Coffin; the others were obtained by combining, with some regard to weight, the observations which he records for the respective districts.

Mean Direction of European Winds.

Ireland, (2 stations)	N.	86°	50′	W.
England (C)	S.	66		"
Scotland, (C)	"	62		"
Sweden, (C)	"	50		"
Norway, (1 station)	"	86	59	"
Denmark, (C)	"	62		"
Denmark, Norway and Sweden	"	62	56	"
Russia	"	52	21	"
" and Hungary, (C)	N.	87		"
Prussia	S.	73	36	"
Germany, (C)	"	76		"
" Southern, (C)	"	82	4	"
Austria	"	64	49	"
Holland and Belgium	"	79	13	"
France and Netherlands, (C)	"	88		"
France, (C)	"	82	50	"
Switzerland	N.	56	54	"
Italy	"	26	43	"

On the Normal Position of the Tidal Ellipsoid.

By Pliny Earle Chase.

(Read before the American Philosophical Society, June 16, 1871.)

The inferences of Laplace, that for certain depths, and of Airy, that for all depths, on a globe covered with a sea of uniform depth and without

friction, it should be *low water under the moon*, rest on the assumption that δr is so slight (see Mec. Celeste 327 iv, 337 iv, 342, 2177, &c.,) that it may be neglected, in order to satisfy equations which would otherwise be impossible of integration. It is true that the radial coördinate of the tide wave, is insignificant in comparison with the coördinates in latitude and longitude, but the cause of that insignificance is not immediately evident, and I can see no reason for omitting, in tidal discussions, any term which would be important in the discussion of planetary motions.

I presume the following postulates will be readily granted.

I. If the earth had no axial rotation, the tide would be one of equilibrium, with high water under the moon.

II. If rotation were to commence after the establishment of the equilibrium tide, the tidal ellipsoid would be thrown forward in the direction of rotation.

III. If the water flowed with such velocity as to be self-sustained, the centrifugal balancing the centripetal force, it would be low water under the moon.

As neither the first nor the third of these conditions is true, it would seem reasonable to infer that the tidal crest should be at some point intermediate between the lunar meridian and the lunar astronomical horizon. The second postulate favors this inference, provided there is any force, other than friction, which would tend to set back the crest of the third postulate.

Such forces, it seems to me, exist in the cohesive attraction and incompressibility of the water, and the rigidity of the earth, all of which tend to shorten the radius vector and increase the velocity of every particle dm, in two of the quadrants, and to lengthen the radius and diminish the velocity, in the alternate quadrants. These successive increments and decrements of velocity terminate at the octants, thus tending to produce low water three hours before, and high water three hours after, the moon passes the meridian.

Airy (Mo. Notices, R. A. S., April 13, 1866), gives a diagram to show, from the position of the points at which *zero* horizontal currents become *plus* or *minus* currents, that it must be low water under the moon. I am unable to reconcile his hypotheses, respecting the direction and velocity of the currents, with actual tidal observations, but even if they are correct, I think we should look to the total action of the moon, rather than to the flow of water at particular points. The water falls in the entire quadrants immediately following, and rises throughout the quadrants immediately preceding the meridian of high water. Would not this continuous action be best sustained if the moon were on the great circle 45° W. of the crest and 45° E. of the trough of the tidal wave, as Newton suggested in his *Principia*, B. I., Prop. 66, Cor. 20?

Note on an Apparent Violation of the Law of Regular Progressive Debituminisation of the American Coal Beds Coming East.

By J. P. Lesley.

(*Read before the American Philosophical Society, June*, 1871.)

In the course of a Geological survey of certain lands in Somerset County, Pennsylvania, it appeared that the beds of coal existing at Ursina held much less volatile matter than was expected. The gas coals of Westmoreland County, which come east as far as Connellsville, only thirty miles west of Ursina (see accompanying map), hold between 30 and 40 per cent. of volatile matters. Three analyses show the Ursina coals to have but 17 per cent., while a fourth gives 22 per cent. This puts the Somerset County coals into the *semi-bituminous* class. Yet the specimens were taken from gangways, a good many years old, and several hundred feet from the outcrop, under high hill cover, at a point on the *western* border of the First Bituminous Coal Basin of Pennsylvania, near the Maryland and Virginia State line. More properly we should say that the Ursina coals lie in the second synclinal of the First Basin. For the Negro Mountain Anticlinal comes up from Virginia and splits the First Basin into two in Pennsylvania. The mountain dies down at Castleman's River; but the anticlinal axis runs on northward. The First Basin is similarly split into two, east of Johnstown, by the Viaduct Anticlinal, which may or may not be an actual prolongation of that of Negro Mountain.

To make the situation understood, the following extracts from my report to the owners of the property will suffice. The accompanying map shows the Backbone of the Alleghany passing by Altoona. This is the eastern edge of the First Bituminous Coal Basin. The two long parallel mountains between Ursina and Connellsville enclose the Second Bituminous Coal Basin of Pennsylvania. The Third, Fourth, and Fifth lie west of it, and the Sixth occupies the northwest corner of the map; no mountains separating the last four.

Figs. 1 and 2 will suffice to show the topographical character of the country, and how the areas of the almost horizontal coal beds have been cut out into patterns, as if with a jig-saw, leaving outcrop edges around all the hillsides, at which gangways enter, and from the mouths of these shutes depend.

Figs. 3 and 4 give vertical sections of the coal measures made with Becker's Barometer; and Figs. 5 and 6 show longitudinal Vertical sections of the hills.

Special surveys like this have more than a commercial value: they reveal, sometimes very unexpectedly, new truths for men of science. It is an advantage to have them placed on record for common use. Too many of the collected facts of science are annually lost for want of publication.

The property surveyed in this instance, lies in my old tramping and camping ground of 1840, during the fifth year of the State Geological

Survey. The report which Mr. James T. Hodge and myself made to Mr. H. D. Rogers, Chief of the Survey, may be found recorded in the Fifth Annual Report (1841), pages 89–92, which I will here recapitulate in the *descending* order of the beds, for convenience of comparison.

The Pittsburgh bed, I, has been eroded from the whole country between the Alleghany Mountain and Chestnut Ridge (at Connellsville and Blairsville) except two hill tops; one, near Salisbury, and the other near Ligonier. It is possible also that a third exception may be discovered in the high hill country south of Johnstown, where a conspicuous bench runs along the hilltops for several miles.

Limestone, 20 feet below I, 6 feet thick in the Ligonier Basin.

Coal bed H, 50 feet below I, 3 feet thick in the Ligonier Basin; 1 foot thick in the Salisbury Basin.

Coal bed G, 100 feet below H, 1½ feet thick in the Salisbury Basin; encircles the highest hilltops in the Ursina Basin with a conspicuous bench. Fort Hill is not quite high enough to have it.

Red Shales between G and F.

Coal bed F, 90 feet below G; generally small; but 4 feet thick in the Salisbury Basin. It forms the high terrace of the Fort Hill.

Mahoning Sandrock.

Coal bed E, "Upper Freeport," 50 feet below F; 2 feet thick, on 2 feet of *Limestone* (over it Shales with *ore-balls*) in Ursina Basin; 3 feet thick, on 5 feet of *Limestone* in the Salisbnry Basin.

Coal bed D, "Lower Freeport," 60 feet below E, 6 feet thick in Ursina Basin; 4 feet, further north; over 10 feet of Sandstone with *ore balls,* in two beds, 7 feet asunder, 11 inches in all. This ore ball horison is very extensive north and south of the River.

Coal bed C, 20 feet below D, 2½ to 4 feet thick.

Coal bed B, 30 feet below C on Cox's Creek, 40 on Laurel Hill Creek (N. Fork), and 60 at Confluence; 4 feet thick over 8 feet of *Limestone* on the river; 1½ feet thick over 4 feet of *Limestone* on the North Fork. Twenty feet above B lie 15 feet of Shales, etc., containing *ore balls,* on Spring Run, below Pinkerton's Bend of the river.

Coal bed, 22 feet below Limestone, on west bank of Castleman's river, ¼ mile above Zook's run ford, and on North Fork at old salt boring; carries 5 feet of Shale containing 1 foot of *ore balls.*

Coal bed A, 70 feet below B; 22 inches thick, at Shroff's Bridge over Castleman's river.

Conglomerate; 30 feet below A; the interval being massive Sandstone.

Such was the general scheme of the Coal measures made out during the old survey, and, however subsequently modified, it has been of incalculable value in all subsequent special, and private investigations. It was a very successful attempt to reduce to system the heterogeneous mass of details collected from all parts of the Bituminous Coal Region of western Pennsylvania outside, or to the east, of the Monongahela River Upper Coal Beds, and of the Alleghany River Lower Coal Beds. It was

A MAP

Showing the Geographical Relations of the Pittsburgh and Baltimore C. C. and I. Co.'s Lands to the surrounding county.

by the collation of these three generalizations, that the first knowledge of the true order of the American Coal Measures was obtained, a starting point and a basis for all the Western Surveys.

It was merely a sketch, however; done hastily, in a single season, and with most inadequate means at our command. In pecuniary power the party fell so low that one of our camps on the North Fork could not be moved, because the whole party could not raise, amongst them all, 37½ cents to pay a farmer's bill for potatoes. A messenger was dispatched to Hanna's at the Turkey-foot, now Confluence, with a faint hope of receiving from the Chief in Philadelphia a remittance. Happily a letter was lying in the Post office which relieved our embarrassments.

Every subsequent private survey has revealed both the general accuracy and the special inaccuracies of the summary statement of the Fifth Annual Report; and there is work for competent local geologists for a long time to come, tracing the principal members of the column, observing their variations, intercalating the more insignificant deposits, and discovering their sudden, and local, and valuable expansions. We know but little yet of the true nature of the genetic relationships of coal, carbonate of lime, and carbonate of iron. But we know that they hold some curiously fixed relationships of the highest economical importance. Every special survey, therefore, should be published, in the hope of taking another step towards a complete understanding of that subject.

It is with this view that I append a special description of a property recently surveyed, stretching for five miles along the North Fork of the Youghiogheny. The North Fork is the Laurel Hill Creek of the Fifth Annual Report. Its mouth and that of Castleman's river makes the Turkey Foot at Confluence. Ursina is a new village one mile up the Fork. The new Baltimore and Pittsburgh Railway is constructed up the south side of the Fork past Ursina, where its grade is 90 feet above water level. It then passes (by a tunnel) through the hills, and continues its course eastward up the North bank of Castleman's River. Ursina is 86 miles by railroad from Pittsburgh, and 243 from Baltimore. There are 6436 acres in this property, and its greatest width of two miles carries it across the centre of the Coal Basin so as to include both dips; which, however, are very gentle, nowhere exceeding 5° and seldom as high as 1°. There is also a gentle lowering of the central belt or axis of the basin southwestward towards the Turkey foot, which has determined its strikingly romantic topography. The hills of nearly horizontal coal measures are 300 to 400 feet high, and the coal beds, etc., pass through them from valley to valley cropping out in nearly horizontal lines along their sides and around their ends. Easier conditions for mining cannot be imagined. And it is in a country quite destitute of faults.

The coal beds belong to the upper part of the Lower Coal System.

The Six Foot Coal Bed outcrops on the hill-side, over the town of Ursina, at an elevation of about 200 feet above the water. Its outcrop keeps at about this height along the east flank of the Ridge (Minder's and Sander's hill) for two miles, up the west bank of the North Fork. It crops out on both sides of Minder's creek, as high up as the forks, where it gets under the water of the run, which descends rapidly.

Fig. 1.—A MAP SHOWING THE AREAS OCCUPIED BY THE SIX FOOT COAL BED IN THE HILLS NORTH OF URSINA.

In the northern part of the property it outcrops on both sides of the

North Fork, at the same elevation of about 200 feet above water-level, for a distance of two and a half ($2\frac{1}{2}$) miles ;

—Along both sides of Smith's creek, for $1\frac{3}{4}$ miles :

—Along both sides of Brown's creek, for $1\frac{1}{4}$ miles :

—Along both sides of May's creek, for $\frac{3}{4}$ mile :

—Along both sides of Sander's creek, for $\frac{1}{2}$ mile :

So that the outcrop of this bed has a run of over ten (10) miles.

In this Northern part of the property it lies also in the best manner possible for mining ; falling gently in all directions towards a central point, or mining location, between the mouths of Smith's and Brown's creeks. The arrows on the map (fig. 1) show the direction of the fall of the coal. The two parallel lines (from R R northeastward) show the central axis of the basin, or deepest part of the coal bed, falling towards S. 30° ± W.

Down this central axis the coal bed falls at the rate of less than 1° ; or, between 60 and 70 feet in the mile. The *fall* from the Krieger bank to the Rose bank, W. S. W. is 150 feet in a little less than a mile. The *rise* from the Rose bank to the crop, up May's creek, northward, is 120 feet in a little over a mile.

Fig. 7

The following openings on this Six Foot Bed have been worked for several years :—

The Krieger Bank one mile up Brown's creek, south side ; 9 feet above the water-bed ; runs in 109 yards, E. 10° S. ; coal mined from several small breasts, not many tons altogether. It is represented in Fig. 7.

Top Rocks : Black Slate	2 feet.
Crumbly Shale	6 feet.
Top coal, with three half inch slates	1 foot.
Main coal, solid bench, with occasional wedges of drab clay	5 feet.
Slate not taken up	8 inches.
Bottom coal, bench not taken up	9 inches.

The following analysis by Mr. Persifor Frazer, Jun., shows a superior percentage of solid carbon with a minimum of ash, sulphur and water :—

Carbon (coke)	79.25	(or $\frac{4}{5}$ of the whole.)
Volatile substances	17.17	(It is therefore not a gas coal.)
Ash	3.11	(an extraordinarly pure coal.)
Sulphur	0.47	
Water	0.55	
Total	100.55	

Total......100.55 : in which the sulphur has been considered exclusively a constituent of the Ash. The specimen (No. 1) was obtained from the Krieger bank, some distance back in the gangway, and midway of the bed, between the roof and floor, and may be considered a fair specimen of what the bed will do when mined on a large scale.

A MAP SHOWING THE TOPOGRAPHICAL CHARACTER OF THE SOUTHERN PART OF THE LANDS OF THE PITTSBURG AND BALTIMORE COAL, COKE AND IRON COMPANY.

(Reduced by Photolithography.)

The ash is remarkably small—the coke very great (nearly $\frac{4}{5}$ths of the whole); and the gas no higher than in Broad Top Coal; water and sulphur about half of one per cent. The small percentage of water in these coals is remarkable.

The coal is friable and comes out much crumbled, and will not bear transportation, but makes a very nice grey even coke. The crumbling shale roof will call for very careful mining and abundant timbering to keep the mine in good order. But while timber is abundant in the district, longwall mining will let the roof fall behind and afford plenty of slate stuff for gobbing up, where needful.

The Rose Bank, opposite the mouth of Brown's creek, facing south, 220 feet above water; shows six feet face of coal, very good, except that there are a few thin layers of slate in the top bench of 12 inches, as before; a coal of 8 inches is said to underlie the bed, as before; roof, again, crumbly shale; coal very friable; it is roughly coked in the open air in front of the mine and makes good coke.

The Kuhlman Bank is opposite to the Rose, on the west side of the valley; and an old mine is $\frac{2}{3}$ mile further west on the same outcrop, and at the same level, 25 feet above the bed of Sander's run. Both are fallen in. The people say that the bed exhibited the same character as on Brown's creek.

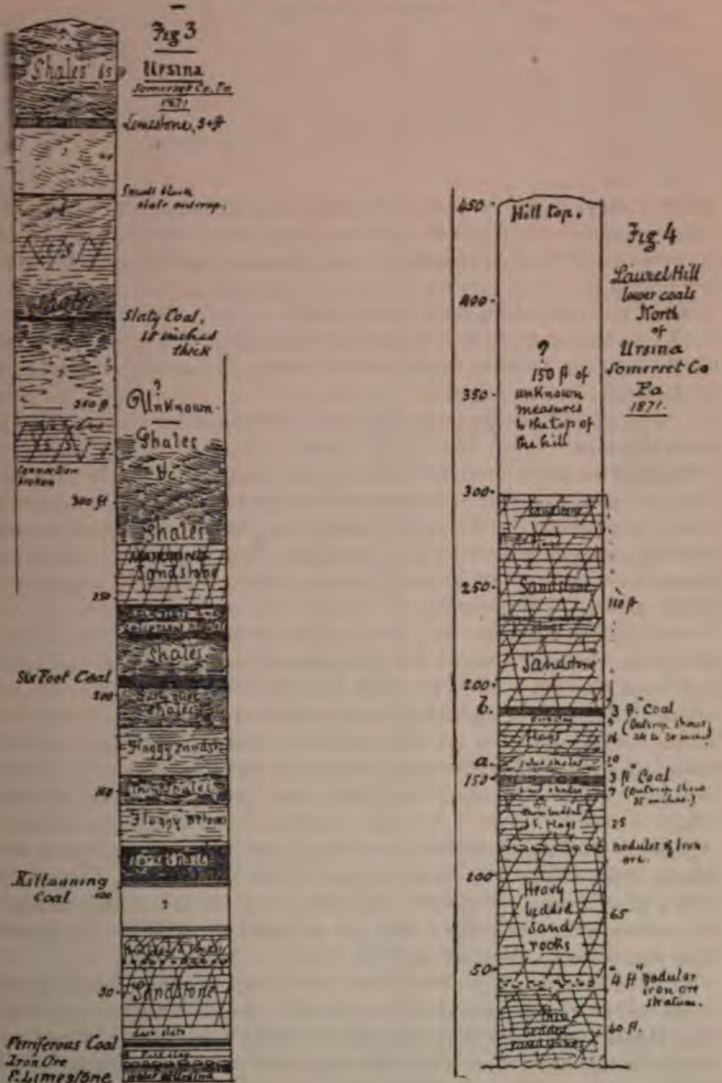
The bed has not been fully opened at the southern end of the property, but I see no reason why it should differ in quality or thickness here from where it is opened further up the North Fork, since it runs with remarkable regularity of thickness and character from the Krieger bank (up Brown's creek), to the Kuhlman bank and the old opening on Sander's creek, a distance of two miles.

Geologically, this bed is the continuation southward, into Maryland, of one of the Freeport beds of the Alleghany River System, having a wide extension through western Pennsylvania, and usually furnishing the best of coal. For want of special instrumental surveys in the country south of the Conemaugh, it is not now possible to assert positively to which of these two Alleghany River Coal beds the Six-foot coal, in southern Somerset county, answers best. Our best gûide, the great lime rock which underlies the upper of these beds, thins out as it approaches the Allegheny Mountain and the Maryland line. But as we have a dark Shale, with limestone nodules, overlying our Six-foot coal bed, and beneath what is probably the Mahoning Sandrock, in the same position as that occupied by the upper of the two Allegheny River beds, the Six-foot coal would seem to be the lower.

If a colliery were established at the mouth of Brown's creek, and three incline planes ascended the ends of Younkin's hill, Menard's hill, and Hyatt's hill, then from the tops of these three planes, three main entries would have three unbroken coal fields straight before them, with a rising coal; in Youngkin's hill rising eastward; in Menard's hill rising northeastward, north northeastward and northward; and in Hyatt's hill rising west northwestward. The point is a rare one for large mining operations.

VERTICAL SECTIONS OF THE COAL MEASURES NEAR URSINA, SOMERSET COUNTY, PENNSYLVANIA, BY FRANKLIN PLATT, JR.

(*Reduced by Photolithography.*)



The gangway entering Menard's hill (at or near the present Rose bank), would command an unbroken area of one and three quarter square miles

of the Six-foot bed, containing the *gross* amount of.........10,500,000 tons,
and by tresseling May's and Brown's creeks at their upper parts where the bed is near their water level, mining might be carried forward into the Ramsbérger and Krieger area, and add.. 1,500,000 tons,
making in all..12,000,000 tons,
commanded by this gangway.

The gangway at the end of Hyatt's hill, would command 2,250,000 tons,

The gangway at the end of Youngkin's hill would command.. 1,500,000 tons.

The amount of coal to be reached in the easiest possible way, and concentrated at one coal dêpot at the mouth of Brown's creek, is therefore evidently larger than the necessities of the largest collieries for an entire generation.

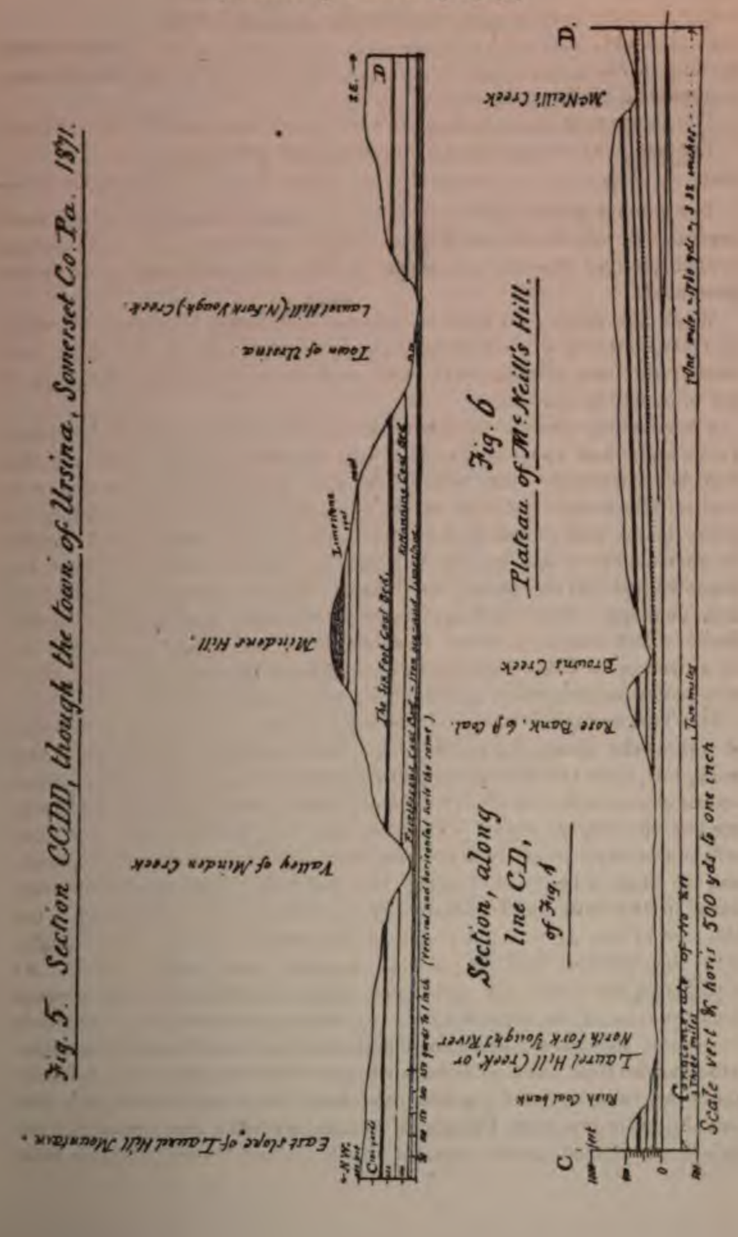
When the main gangways become inconveniently long, their air-ways along the outcrop will afford the most convenient outlets for slack and waste; and new gangways can enter any where, because the drainage of the mine will be perfect.

A fine colliery can also be established at the forks of Minder's Creek, a mile and a half above its junction with the North fork. Here the Six Foot bed strikes the water level of the run; gangways may be driven in horizontally west, northwest, north, northeast, and east, commanding an entire square mile of coal lands, or six million tons of coal. The tramroad for such a colliery will be, say $1\frac{1}{4}$ miles long, with a grade of 10, or between 90 and 100 feet to the mile, which may be lessened by judicious arrangements. This point has another advantage: it will permit *all* the Sander's Hill coal to come out, down grade. I never saw a more beautiful situation for a first class colliery on bituminous coal. Nor do I know of a better coal on which to establish a great coke trade.

The Turkey-foot is likely to become a second Johnstown, in the way of iron works, occupying precisely the same position, geographical and geological, upon the Baltimore and Pittsburgh through railway line, which Johnstown occupies on the Philadelphia and Pittsburg through railway line, as the map on page 3 will show; and just as Blairsville and Connellsville occupy precisely analogous situations, geological and geographical, to each other. At Ursina, the coal beds, iron ores, limestones occur in the hills in the same way that they do at Johnstown; the hills are of the same shape; and the minerals lie at the same angles with the horizon, and at similar heights above water level. At both places the Pittsburgh and Green county coal beds are absent, swept from the tops of the highest hills. At both places the blue carbonate iron ore of No. XI. underlies the conglomerate on the flank of the mountain near the top. And as Johnstown gets brown hematite ores from the limestone valleys of the Juniata, and fossil ore from Frankstown, and Lake Superior ore from Cleveland, to mix with the ores under the coal beds in its hills, so Ursina can get fossil ore and brown hematite from

HORIZONTAL SECTIONS OF THE COAL MEASURES NEAR URSINA, SOMERSET COUNTY, PA., BY FRANKLIN PLATT, JR.

(Reduced by Photolithography.)



Cumberland and other points on the Potomac, and the same Lake Superior ores via Pittsburgh, to mix with same iron ores which lie in the hillsides of Castleman's river and Laurel Hill Creek.

Two other coal beds range through the property. The Kittanning bed 100 feet lower down the hillsides than the six foot; and the Ferriferous bed, nearly at water level. Two other small seams of coal exist in the hill tops, belonging to the middle or upper part of the Barren Measures, under the Pittsburgh Coal Bed.

The Kittanning Bed averages 2½ feet, and is best opened at Ursina. This bed outcrops all around the hill sides, north of Ursina; but goes beneath water level of Minder's Creek, two-thirds of a mile up from its mouth. It outcrops all the way up the North fork.

A thirty inch coal bed is opened at the Rush Bank, 1½ miles above the mouth of Brown's Creek, (fig. 1), 25 feet above the water of the North fork (Laurel Hill Creek). This bed underlies the Six Foot about 100 feet, and is the Kittanning coal bed. It shows 30 inches of good hard coal, with 15 inches over it of slate mixed with thin coal seams, and a roof of soft shales, requiring careful timbering. Its floor is a massive sandrock, without a particle of intervening fireclay. The bed has only been stripped at its outcrop; but yields cubical masses of very firm coal.

This is the usual Cannel and Block Coal bed of the country.

The Ferriferous Bed, (so called, not because it carries, itself, any iron, but because it always comes into the measures just above a limestone which is called ferriferous because it carries on its upper surface the great iron ore deposite of north west Pennsylvania, especially in Clarion, Venango and Armstrong Counties), averages 2½ feet, and lies just above water level at Ursina. It sinks beneath water level going west, down the fork. It has been opened, also on the property, at the mouth of May's Creek, and at the mouth of Brown's Creek, on both banks of the creek. On the north bank 25 inches of coal is visible, with a 3 inch slate parting. On the south bank 20 inches of coal, 3 inches slate, 5 inches of coal; roof, 2 feet of iron-stained shales supporting 30 or 40 feet of sandstone; floor, hard slate; under this, a thick bed of fire-clay, containing nodules of iron ore; under this, limestone, said to be 18 inches thick.

The bed is not thick, but its quality of coal is good; the mineral coming out in solid blocks, and apparently adapted for the iron manufacture. Mr. Frazer has made two analyses of it, with the following results:

	No. 1.	No. 2.	Mean.
Volatile matters and water......	17.12	17.13	17.125
Water alone..................	0.30		
Fixed carbon..................	68.20	68 87	68.535
Ashes..........................	14.68	14.00	14.34

Another specimen taken from the Widow Croll's bank, near the mouth of Brown's Creek, shows the same character of this lower coal, above the limestone; equally free from water and sulphur as the Six Foot bed; more gas (equal to Alleghany Mountain Coal in this particular); a large quantity of ash; and 3-5ths of it coke.

Water	0.55
Volatile substances (Gas)	21.90
Carbon (Coke)	60.98
Sulphur (in ash)	0.62
Ash	15.95

The Ferriferous coal is opened also at the head of Smith's Creek, on both banks of the creek. On the south side a pile of half burned lime, shows how strongly ferruginous the limestone stratum is. On the north side, the outcrop exposed by digging, shows two feet of coal, the upper foot slaty; 1 foot of clay, with nodules of ore, in the roof; over this again 1 foot of sandstone; then one foot of dark slate; then a heavy sandstone. The floor is a thick bed of fireclay, the upper 3 or 4 feet being closely filled with nodules of iron ore.

At the base of the Ramsberger Hill and on Bogg's Creek, at the north end of the property, this coal, and another bed 30 feet below it, (see section fig. 4), apparently 24 to 36 inches thick each, and mixed with slate, occur again, and no lower measures are visible anywhere. The conglomerate at the base of the coal measures is just underneath them; the same which may be seen in the gap below Confluence, making a great arch in the mountain.

The fire clay under the ferriferous coal is usually about 4 feet thick.

The Ferriferous Limestone shows about 18 inches thick on the east bank of the North fork, but its general thickness I do not know. It is the same deposit which on the Slippery-rock and Beaver River country furnishes the *soda*-lime for the Pittsburgh works. On Smith's creek the farmers have tried to burn this limestone for use, but failed, and the calcined fragments show that it contains much iron, and may, therefore, make a superior blast furnace flux.

This bed underlies the country about water level, and is very consistent with the character given above. At Ursina it shows the same slate parting near the bottom, and the same underlying beds of fire clay, iron ore and limestone. It will probably play an important part in the future development of the Turkey foot district.

A small (2 inch) layer of nodules of iron ore occurs about 65 feet above water level at Ursina, but it is, of course, worthless at this point.

A small coal bed outcrops 127 feet above the Six Foot bed, over the Krieger bank.

One of the limestones of the upper part of the barren measures comes in, between 475 and 525 feet above water level, near the summit of Minder's Hill, and extends through the hill tops of the property west of the North fork. It is at least 5 feet thick, and ferruginous.

About 100 feet below this limestone is a thin coal vein, very slaty, and good for nothing. There is also a bed of coal-slate 40 feet under this upper limestone.

The analyses given above are important. They oppose the law of *progressive bituminisation westward* of the coal beds.

That both the 6 foot and the 3 foot Ursina beds, situated at the western limit of the 1st Bituminous coal basin, should have only 17 per cent. of volatile matters,—not more than the coals of the Broad Top Region, lying one hundred miles to the east of Ursina,—is truly remarkable. The Broad Top beds are tilted and faulted abundantly. The Somerset County beds are almost perfectly undisturbed. The coal in one gangway showed 22 per cent. of volatile substances. But even this is no greater than the coals of the summit of the Alleghany Mountain, and the coals of the Cumberland Coal Region.

No proper scheme of the *rates* of *debituminisation* to *casting*, and to *disturbance*, can be obtained until all the analyses of each bed in the series of Coal Measures shall be tabulated apart from the rest. We may then expect to learn something also respecting the influence of specific vegetation upon the percentages of coke and gas.

But in the outset one source of error must be guarded against. The specimens of coal from which the foregoing analyses were made, were obtained in the walls of old gangways. It is possible that they had been long enough exposed to the air to lose some of their hydro-carbons by spontaneous evaporation. The rate at which this goes on in coal mined and exposed in heaps, is variously stated by those who have investigated the subject.

Dr. Richters made a recent communication to a German Journal, in which he states his opinion, that the weathering of coal depends upon its ability to absorb oxygen, converting the hydro-carbons into water and carbonic acid. At a heat, say of 375° F, only 5 or 6 per cent. of the carbon accepts oxygen, the rest seems to show little or no disposition to affine with it. The process is apparently dependent upon the per centage of hydrogen. But with coal, cold, or at ordinary temperature, the oxydation is so slow as to be imperceptible, even after exposure for an entire year. He says moisture has no accelerating effect, unless pyrites is present in quantity. Pure coal, heaped up for nine months or a year, unprotected by the weather and not allowed to become heated, is changed no more than it would be in a perfectly dry place.

Herr Grundmann, of Tarnowitz, on the other hand, has recently published elaborate experiments proving the effects of exposure on bituminous coals to be most serious. Coal which he exposed for nine months, lost *fifty per cent.* of its value as fuel. His conclusions excited such doubts, that his experiments were repeated, in connection with Herr Varrentrapp, of Brunswick, who proved, by laboratory experiments, that oxydation took place at common temperatures. Three months sufficed to rob coal, kept uniformly at 140° C. (284° F.) of *all its Carbon*, a heat less than that evolved in coal heaps exposed to the air.

Grundmann proved that the decomposition was the same in the middle of the heap as at the surface, and reached its maximum about the third or fourth week; that half of the oxygen was absorbed during the first fourteen days; that a coal poor in oxygen absorbs it most rapidly; that moisture is an important condition; that coals making, when freshly mined, a firm, coherent coke of good quality, make, after even only *eleven days'* exposure, either no coherent coke at all, or coherent coke of quite inferior quality. For gas purposes also, the coal is greatly injured.

It is evident that these facts have an important bearing on the value of the analyses given above.

Note on the TITANIFEROUS IRON ORE BELT, *near Greensboro, North Carolina.*

By J. P. LESLEY.

(*Read before the American Philosophical Society, June* 16, 1871).

I embrace the oportunity to exhibit the structure of this interesting ore belt, afforded by a recent survey of the lands through which it runs for thirty miles; lands owned or leased, by an association of gentlemen, known as the North Carolina Centre Iron and Manufacturing Company of Philadelphia, of which Mr. Thomas Graham is President.

The photolithographed cuts at my command, were reduced in fac simile, from my drawings, by Bien's process, and are sufficiently clear to ex-

FIG. 1.

hibit so much of the geology of the country as is necessary to the right classification of the ores in question. The chief interest which the ores

have for us, comes from the analyses given below. But the relations which these ores bear to other ores of similar composition, cannot be understood without a general description of the district.

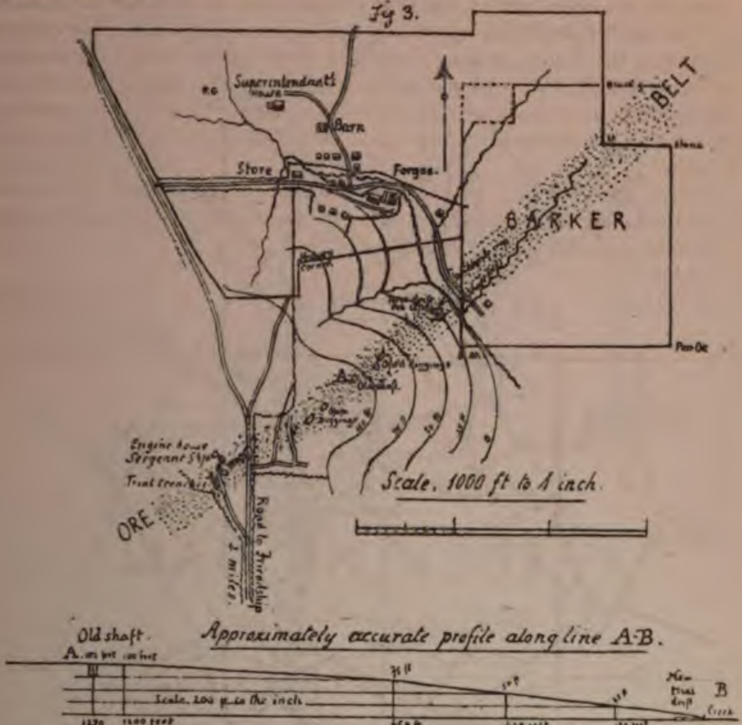
Fig. 1, will inform those who are not acquainted with American geography, of the geographical relationship of the Greensboro district to the Atlantic sea-board and to the Blue Ridge Range of Primary mountains.

The two Triassic belts containing coal appear on this map ; the eastern including the Richmond Coal Basin and that of Deep River ; the western that of Dan River, prolonged northward across the James River below Lynchburg, and originally connected with the continuous out-spread of the Trias in Maryland, Pennsylvania, New Jersey, and the Connecticut Valley.

Fig. 2 gives, on a larger scale, the position of the ore-belt in Guilford and Rockingham Counties, N. C., and the radiation of railways, already running, or under survey, from Greensboro.

FIG. 2.

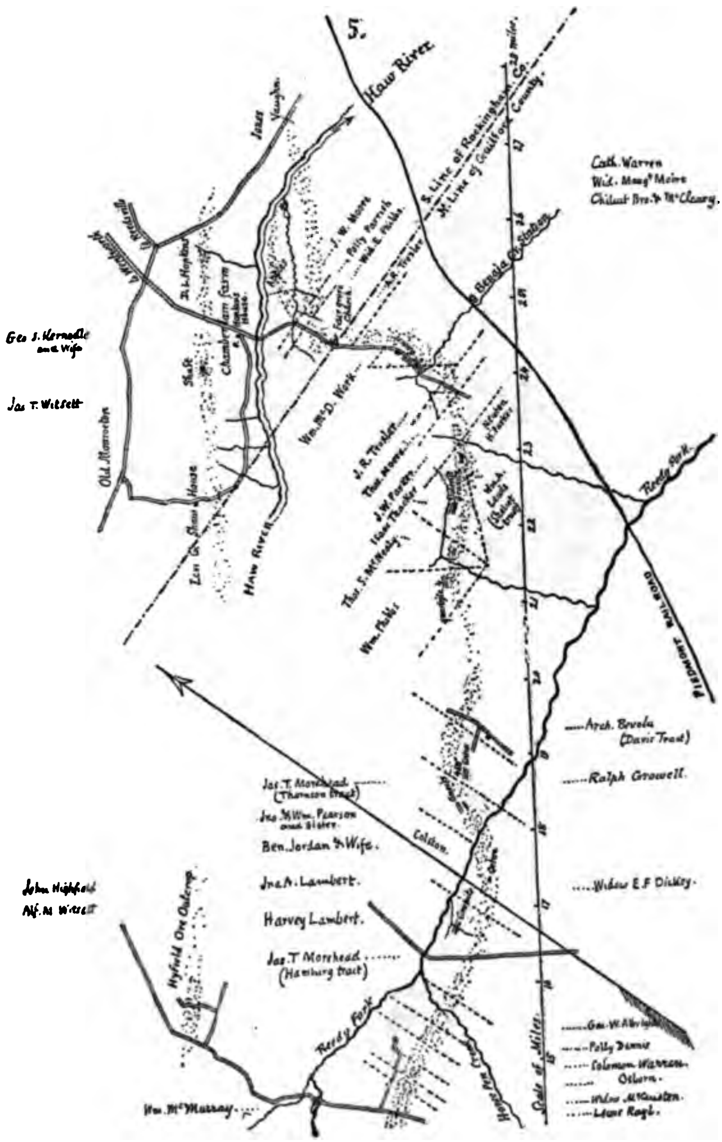
Fig. 3 is a special map of the ore-belt where it passes the Tuscarora forges, and has been most thoroughly tested. Here is the Sergeant shaft. The accompanying section will be of use, as it furnishes a carefully measured example of the numerous hill slopes which compose the surface of the country.



Figs. 4 and 5 continue the mapping of the ore-belt on to the head-waters of Deep River, to the southwest; and to the northeast as far as the Haw River. The general straightness of the outcrop for 15 miles, and more, is remarkable. The whole length surveyed was about 30 miles.

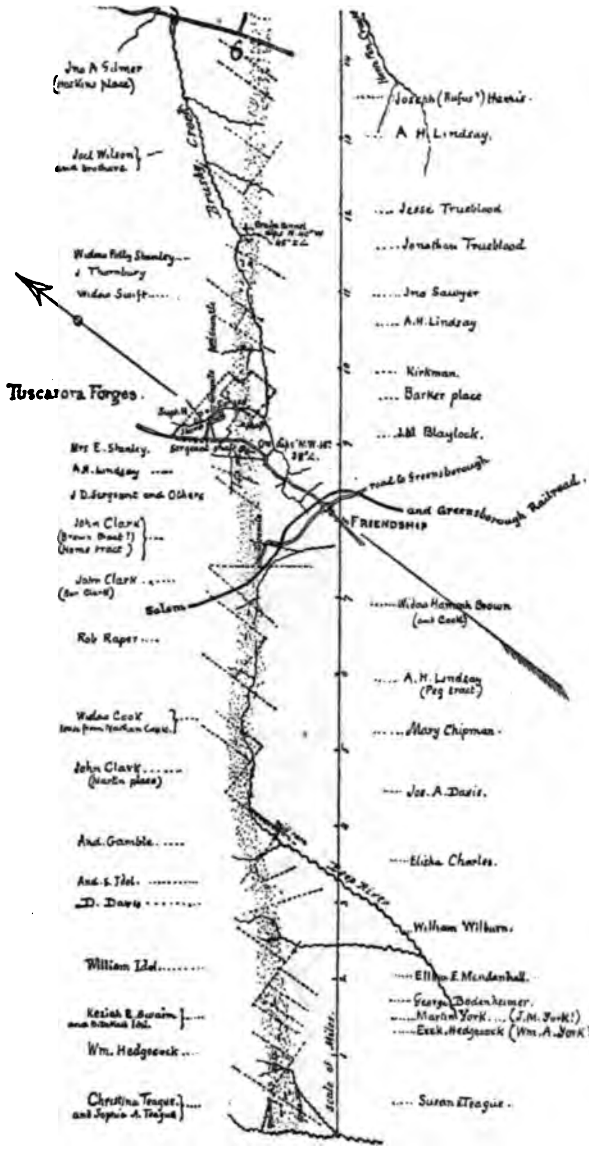
This part of North Carolina is occupied by some of the oldest rocks known; the same rocks which hold the iron ore-beds of Harford Co., Md., and Chester Co., Pa., and the gold ores of Georgia, North Carolina, Virginia, and Canada. The gold mines of Guilford Co., N. C., are opened alongside of, and not more than ten or twelve miles distant from, the Tuscarora iron ore-belt. See figure 2 above. Both the gold and iron range continuously with the exception of one break, in New Jersey, from Quebec, in Canada, to Montgomery, in Alabama. The gold and iron-bearing rocks are: granites, gneissoid sandstones, and mica slates, all very much weathered and decomposed; and that to a depth of many

FIG. 4.



Haw River
Cath. Warren
Chilcut Bro. & McCleary.
Geo. J. Kernodle and Wife
Jas. T. Witsett
Haw River
Reedy Fork
Arch. Brooks (Davis Tract)
Ralph Gorrell.
Jas. T. Morehead (Thomson tract)
Jno. & Wm. Pearson and Sister.
Ben. Jordan & Wife.
Jno. A. Lambert.
Harvey Lambert.
Jas. T. Morehead (Hamburg tract)
Widow E F Dickey.
Wm. McMurray
Reedy Fork
Scale of Miles
Polly Dennis
Osborn.

FIG. 5.


Tuscarora Forges.
Friendship
and Greensborough Railroad.
Salem
Jesse Trueblood
Jonathan Trueblood
Kirkman.
Barker place
Mary Chipman.
Jos. A. Davis.
Elisha Charles.
William Wilburn.
Susan Teague.
William Idol
Wm. Hedgecock
And. Gamble
Rob Raper
Scale of Miles.

fathoms beneath the present surface. The solid granites are decomposed least; the mica slates most. All contain iron, which has been peroxidised and hydrated, in the process of decomposition of the whole formation, and dyes the country soil with a deep red tint. Or, more properly speaking, the surface of the whole country is streaked with belts of red and gray soil, following the outcrops of the more weathered and the less weathered beds. But, even in the gray belts, the solid granite, or gneiss, or sand-rock, seldom appears at the surface, although outcrops of them can here and there be found; and a number of these outcrops are designated upon the map, close to, and on each side of, the Tuscarora ore-belt outcrop. The surface of the country, therefore, is a smooth, soft, undulating plain, broken by gentle vales, the bottoms of which are never more than one hundred feet below the plain, and commonly not more than half that depth. The roads show how readily the rock soil absorbs water and dries off again. The soft, mouldered condition of all the rock strata, to depths of 50 or 100 feet, is therefore easily understood. But the rapidity with which the erosion of the land goes on is surprising. An old bridge, built a century ago, over a stream near the Quaker Meeting House, and of course several feet above the water, is now buried to a depth of 6 feet beneath the surface of its little meadow.

Two general results follow from this universal ancient rainwater decomposition of the surface of the country, to the depth of the deep valley drainage plane:—

1. All sulphur, &c., has been washed out of the ore-beds, leaving the ore remarkably pure. Whether the ore-beds, when followed down for hundreds of feet or yards into the earth, will be found to keep a notable percentage of sulphur, cannot now be known. But, whatever sulphur was originally combined with the iron, has been removed from the upper parts of the beds.

2. The decomposition of the rock strata, which inclose the ore-beds, has weakened them so that extra care must be bestowed upon all shafts and tunnels sunk or driven to win the ore, to keep them safe for mining operations. When the more solid strata, at various depths beneath the surface, are reached, mining operations will be as simple and safe as in any other region.

The hills being never more than about one hundred feet above the valley-bottoms, the ore-beds can be mined by horizontal self-draining adits, or tunnels, only at well selected points. But, seeing that the ore-beds run in straight lines for long distances, a large quantity of ore can be thus taken out, for some years to come.

The belt of outcrop of ore-bearing rocks has a uniform breadth of several hundred yards, and, I believe, a uniform dip towards the northwest, or north-northwest; although there are appearances (to be stated in detail hereafter) which would lead the casual spectator to conclude that the outcrop was double, and not single; that is, that the belt is synclinal, the ore-beds descending from the southeast side, downwards, northwestward to a certain depth, and then rising again to the surface. But the general

considerations against this view are so strong, that I reject it without much hesitation ; and I give my reasons further on.

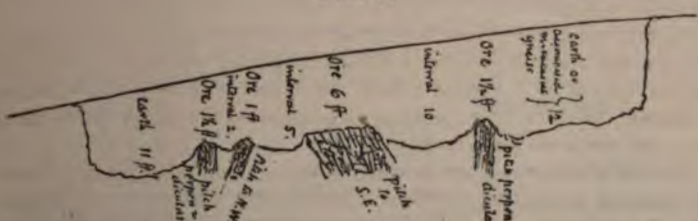
The map, however, shows another ore belt running nearly parallel with the Tuscarora Forge Outcrop, and at a distance of three miles from it. This is called the Highfield, or Shaw Outcrop. Beyond the Haw River these two belts approach each other, and are believed to unite in Rockingham County. This, and other considerations, make it almost certain that the Shaw belt is the Northwest outcrop of a synclinal basin, three miles wide, and that the Tuscarora Belt is the Southeast outcrop. If so, the Tuscarora ore beds descend, with a N. W. dip, to a depth of a mile beneath the surface, and then rise again as the ore beds at Highfield and Shaw's ; thus :

FIG. 6.

Many of the outcropping ore-beds are, to all appearance, vertical; others dip irregularly, some southeast, others northwest ; some steeply, others gently. But all these are extremely local variations, confined to a few feet or yards of depth, and will not invalidate the general uniformity of northwest dip of the whole Tuscarora Belt, and southeast dip of the whole Shaw Belt.

The following section of beds on (fig. 7) the Widow McCuisten plantation (14—15 miles), in a trench cut at right angles to the outcrop, 50 feet long, and from 4 to 8 feet deep, will illustrate these irregularities :—

FIG. 7.

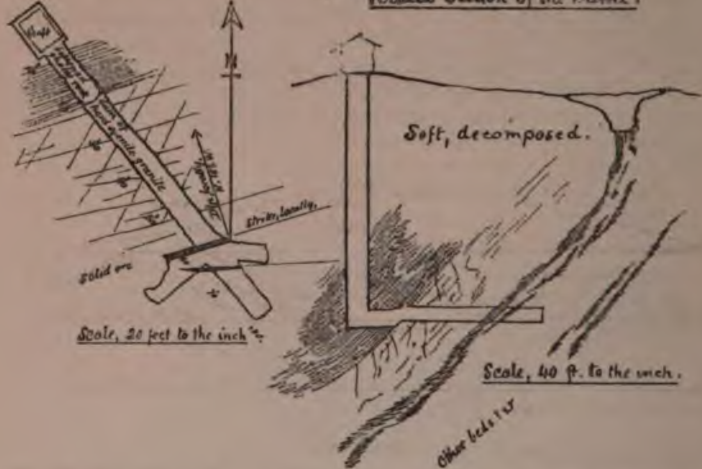


Similar irregularities are noticeable everywhere. The miners say that the pitch of the outcrop of the ore-bed worked in the Sergeant Tunnel and Shaft (9) was southeast for some distance down, after which it took its regular northwest dip, such as it now has in the shaft and tunnel at a

depth of 100 feet. Besides which, there are in fact two beds cut in this shaft-tunnel, the smaller bed underlying the other, and with a dip which would carry the two beds together at some distance beneath the floor.

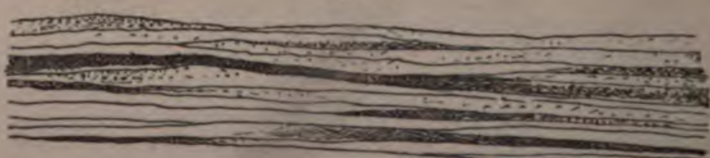
Fig. 8 Ground plan of the Sargeant Shaft and Tunnel.

Vertical Section of the Same.



These ore-beds are not ore-veins; for they do not cut through the rocks crosswise. They have no well defined walls; they have no selvages; there is no gangue-rock different from the rocks on each side; they have, therefore, not been formed in crevices subsequently in a later age after the uptilting of the formation; they have neither been ejected volcanically from below, nor infiltrated aqueously from above, nor secreted chemically from the wall rocks; in a word they are not at all "veins." On the contrary they are "beds;" beds deposited, like the rest of the rocks, in water; deposited in the same age with the rocks which hold them; are in fact rock-deposites highly charged with iron; and they differ from the rest of the rocks of the formation in no respect, excepting this: that they are *more highly charged with iron.* I can best represent the facts of the case by an ideal diagram of the rocks of the ore-belt in their original horizontal position, somewhat thus:

FIG. 9.

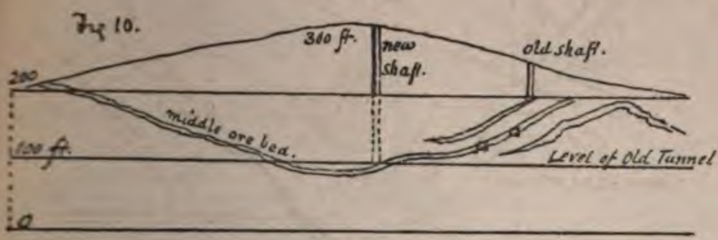


In fact all our primary (magnetic and other) iron-ore beds obey this law.

They are merely certain strata consisting more or less completely of peroxide of iron, with more or less intermixture of mud and sand, which, when crystalized, fell into the shape of feldspar, hornblende, mica, quartz, etc., etc.

To show that this is not mere theory, but actual fact, I compare here the section of magnetic iron-ore beds worked out on Durham Creek, near Easton, Pennsylvania, a map and sections of which can be seen by reference to W. Brook's part of the New Jersey Geological Report, by Prof. Cook, 1868, page 332, and given in Fig. 10.

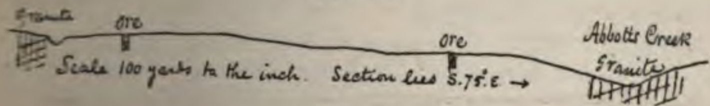
FIG. 10.



It follows then from the above mentioned facts:

1. That *the Number* of *Ore beds* in such a formation cannot be stated. A large number of rock strata will become ore-beds locally. But there will always be a particular part of the formation more generally and extensively charged with great quantities (or a high percentage) of iron than the rest. In other words, the iron of the formation as a whole is concentrated along one or more lines. This is evidently the case with the Tuscarora Ore Belt, as is shown by the almost perfect straightness of the outcrop of the Sergeant Shaft ore-bed, where its outcrop has been opened for half a mile northeast of the shaft. There are two principal beds cropping out on the Teague plantation, at the (southwest end of the belt), both vertical, and about 300 yards asunder, thus: Fig. 11.

FIG. 11.



Another instance occurs on the Trueblood plantation (12 miles), where the two ore-beds appear to be only about 200 yards apart at their outcrops, and seem to dip different ways, which I explain by reference to the false surface-dip of the Sergeant Shaft bed. The Trueblood section is as follows:

FIG. 12.

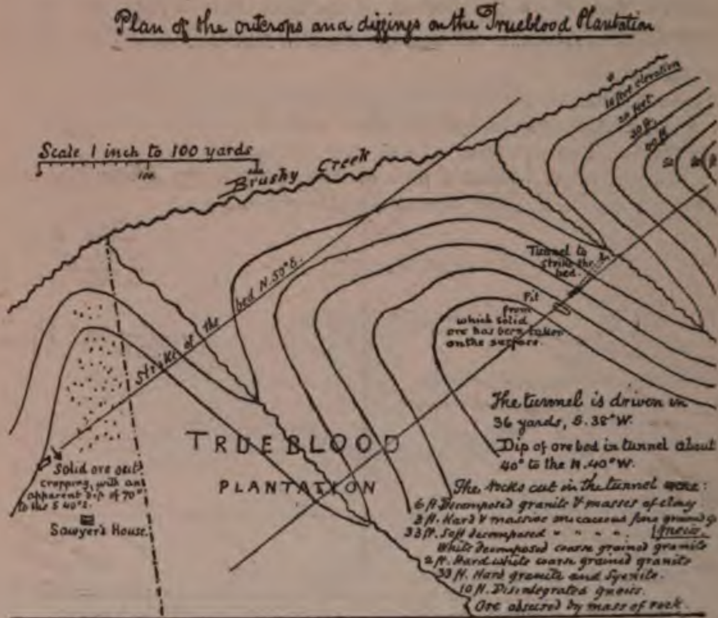
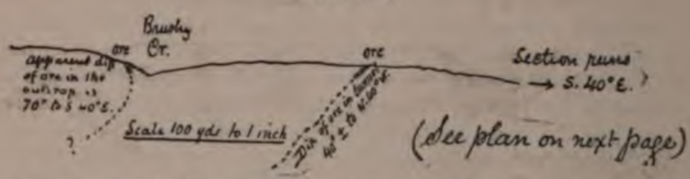


FIG. 12a.

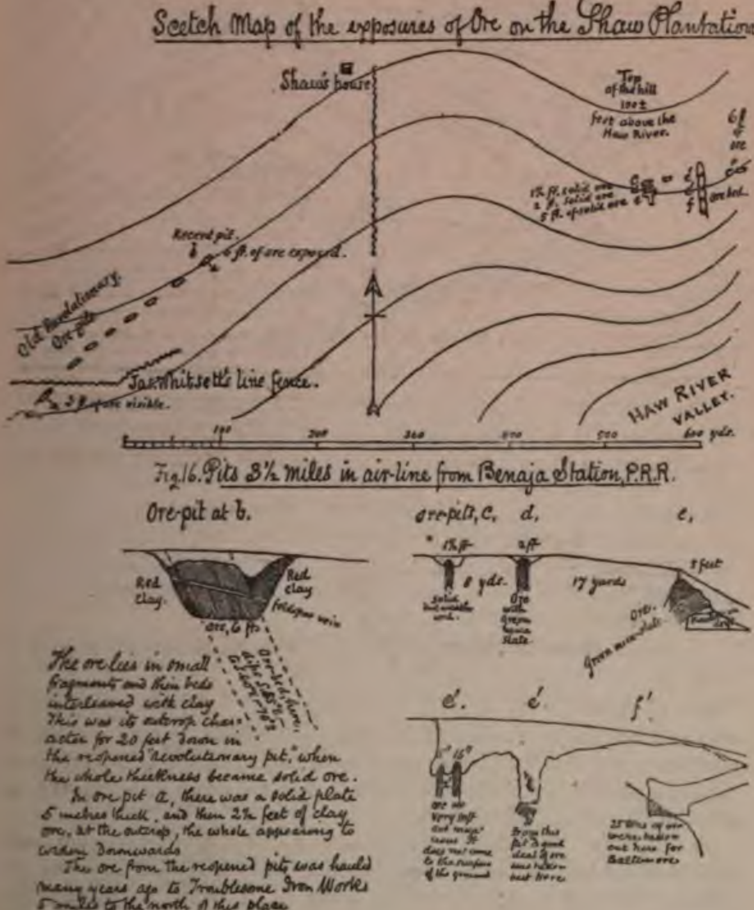


But nowhere do the number and irregularity of the ore-beds show more plainly than in the openings made on the Shaw range, and Shaw plantation, as will be seen by the plans and sections of the old revolutionary diggings, and the late shafts and trial trenches opened on that property, as given in Fig. 13, etc., further on.

On this Shaw Plantation, where three or four distinct and parallel beds have been opened, as seen in the preceding chart and diagrams, the direction of the bed changes somewhat, being N. 30° to 35° E., at the "Old Revolutionary Pits," and more nearly easterly at the openings recently made by the Company. The whole course tested amounts to over half a mile. The beds at the outcrops vary in thickness from one to six feet. At c″ the ore-bed is full 6 feet across solid ore—a very green, chloritic, mica-slate rock-ore. In this run of 800 yards, there are, *apparently, two hundred thousand tons above water-level,* in the one six-foot bed.

The ore is good. The outcrop runs along the top of a hill, about one hundred feet above the bottom of the Haw River Valley, and can be tunnelled into at that depth. There are apparent variations in the

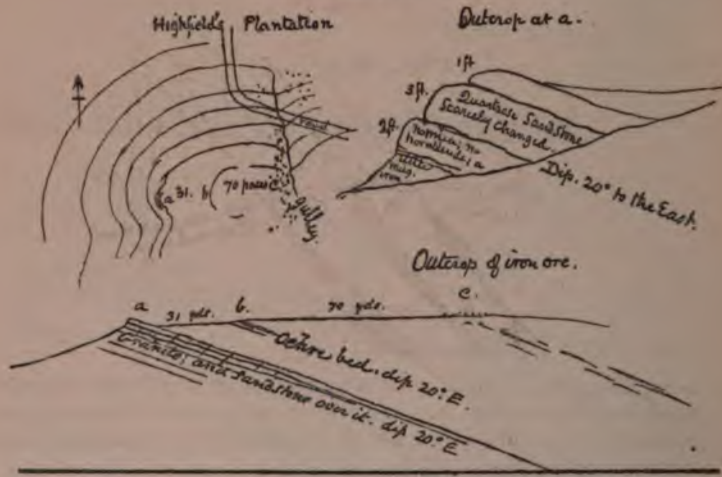
FIGS. 13, 14, 15, 16.



dip, some of the outcrops seeming to be vertical, whereas the principal part of the mining has already shown a distinct dip towards the southeast and south. In pit f of the chart, the dip seems to be scarcely 40°.

The Highfield outcrop shows that the ore beds lie in this Shaw range, at a much gentler angle than in the Tuscarora range; thus:—

Fig. 14.



The distribution of pieces of ore over wide sections of the outcrop of the ore-belt, is a notable thing. Along certain narrow lines inside the belt, are to be seen multitudes of fragments lying on the ground, which have been left behind when the rest of the rock has been mouldered and washed away. And sometimes these fragments are a foot or more in diameter, although commonly smaller. Formerly, the ground was abundantly covered with them, but they were the first ore sought and used, and most of the large pieces and patches have disappeared during the war years of 1861, '2, '3 and '4.

Large pieces on the surface are the best evidence we can possess (in the case of unexplored ground) that the beds are of a good size, for they have come from those portions of the beds (a, b, c, &c., in the accompanying diagram, (fig. 15), which have been destroyed in the general lowering of the surface of the country. There is no reason why the parts of the beds left under the present surface (a′, b′, c′, &c.), should not yield as large masses as the parts a, b, c, which have been mouldered away.

2. *The Size of the Ore Beds* varies as much as their number. They consist of strings of lens-shaped masses, continually enlarging and contracting in thickness, from a few inches to six and eight feet. The principal beds may be safely estimated on an average of four feet, or 176,000 tons to the mile, with an average breasting of 60 feet above water level. It is needless to say that an equal amount would exist beneath water-level, for every sixty feet sunk on the bed.

3. *The Quality of the Ore.*—It belongs to the family of the Primary Ores. It is very similar to the New Jersey ores which are so extensively

mined for the furnaces on the Lehigh river. It is a mixture of magnetic crystals, and specular plates of sesquioxide of iron, with quartz, feldspar and mica, in a thousand varying proportions. Sometimes the bed will be

Fig. 15.

composed of heavy, tight, massive magnetite (or titaniferous magnetite), with very little quartz, &c. At other times the bed will be composed of a loose, half-decomposed mica slate, or gneiss rock, full of scattered crystals of magnetic iron.

The ore is, in fact, a decomposible gneiss rock, with a varying per centage of titaniferous magnetic and specular iron ore, sometimes forming half the mass, and sometimes constituting almost the whole of it.

The compact varieties will yield between 50 and 60 per cent. of pure iron, as in the case of the ore now being mined in the Sergeant Shaft, near the Forges. Mr. Frazer's analysis of this ore is as follows:

Magnetic oxide............73.56..........[Iron.........53.27 p. c.]
Titanic acid................12.58.............[Titanium.....6.62 p. c.]
Residuum of quartz, &c.............12.86—with a trace of sulphur.

The specimen was obtained from the tunnel, a hundred feet beneath the surface, and shows an intimate mixture of crystalline titanic ore, magnesian mica, a little hornblende, a little labradorite, and a little specular iron.

This kind is difficult to smelt in the high-stack blast-furnace; but makes the best iron in the world when smelted in the Catalan forge; and is of great value for the lining of puddling furnaces. It serves the same purpose as the Lake Superior ore, which is brought in large quantities to Pittsburgh, and the surrounding district of Eastern Ohio and Western Pennsylvania, for lining puddling furnaces, and to mix with poorer ores in the blast-furnaces. Formerly, in the E. Ohio Mahoning district, the mixture was: one-fourth Lake Superior, one-half coal measure ore, and one-fourth mill cinders. Since the organization of the Lake Superior Iron Ore Trade, sufficient quantities come forward to enable the iron masters to mix one-half Lake Superior. The Sharon Furnace on the Beaver river runs wholly upon Block Coal and Lake Superior Ore. The titaniferous magnetic ores of the Ottawa region, in Canada, are also brought by a long and expensive route to Pittsburgh, to mix with Pennsylvania

ores. These Canada ores are of the same geological age, and of the same mineral character, as the Tuscarora ores under consideration.

Trial of the ore has been made by Mr. Nathan Rowland, at his works in Kensington, Philadelphia. Five tons were forwarded for trial as lining to puddling furnaces. Mr. Rowland expressed his opinion that it stood up three times as long as the Champlain ore, which he uses for that purpose. The difference is due to the superior compactness of titaniferous magnetite over that of pure crystalline magnetite.

I have said above, that the Tuscarora ores are essentially like those of Northern New Jersey. I referred to their age, situation, consistency, and general composition. But they have a peculiarity; they hold a notable per centage of *titanic acid.* The New Jersey ores seldom possess this property, and, in any case, only in a low degree. The Canada ores, and the ores of South Sweden, hold large quantities of titanic acid; even as much, sometimes, as between 30 and 40 per cent. A small—a very minute—quantity of titanium in pig-iron is believed to add greatly to its value, increasing its hardness and firmness, and its ability to stand wear. The Canadian ores were introduced to the Pittsburgh iron works for this end. But, seeing that almost all the titanic acid in any iron ore passes off in the slag, leaving a very small quantity to unite with the pig metal (sometimes in scattered crystals), it follows, that ores, which have an excessive quantity of titanic acid, cannot afford a high per centage of pig metal. It is much better to have an extra 20 per cent. of silex and alumina, potash or lime, in the ore, than an extra 20 per cent. of titanic acid; for these will make the ore easy to smelt, whereas the titanic acid makes it difficult to smelt; requiring a much higher heat in the stack to decompose than does oxide of iron.

There is no question that titanium in iron ore favors the production of iron peculiarly suited to conversion into steel. The English steel trade has always largely depended on Swedish iron; and I believe that the titaniferous ores of the United States (and they are far from abundant,) will become annually more and more valuable, on account of the increasing demand for the best iron for steel-making purposes. If these ores were smelted in large quantities in first-class anthracite furnaces, I do not think this particular value would appear; the small Swedish blast furnace must be used, or the Catalan forge.

Although the action of titanium upon iron in metallurgy is an obscure subject, something is known of it by actual experience.

J. H. Alexander, of Baltimore, in his report on the Manufacture of Iron, gives analyses of certain cinders, among which is one obtained in the smelting of a primary iron ore, containing, he says, 11 (eleven) per cent. titanic acid: the analysis is as follows:—

Silica	31.1	*Oxide of Titanium*	9.0
Magnesia	34.2	Protox. manganese	4.4
Lime	14.1	Protox. Iron	1.0
Alumina	8.9		

The ore, he says, was hard to smelt, and the pig-iron hard to work, but when properly made, is peculiarly adapted to the manufacture of steel.

The explanation is as follows:—Titanic acid will not combine readily with either the acid or the alkaline oxides. In every ton of ore (holding 10 per cent. of it) 320 lbs. of this neutral stuff exists, or ($1\frac{1}{2}$ tons of ore to 1 ton of iron) 330 lbs. of it in every ton of iron. If only 1-10 of this (or 33 lbs.) remains in the furnace, the gradual accumulation blocks it up. The only solvent of it are the double silicates of iron and lime, or iron and alumina and lime, or iron and potash and lime, &c. To make these double silicates, we must *waste* a good deal of iron. But the one object of the blast furnace is to *save* all the iron, and the best cinder is that which has no iron left in it, all the iron of the burden having gone down into the hearth as pure metal (with enough carbon to make it fusible). The Catalan forge, on the contrary, wastes iron, and its cinders are so rich in iron, that they are often worked over again; hence, titanic acid is carried off, and does not obstruct the hearth. The forge fire is, therefore, the best to reduce titaniferous iron ores. But the blast furnace can smelt them also, if the heat be kept low, and some of the iron be allowed to go to waste in the cinders, to carry off the titanic acid and cinder mass. The object then, must be to make the utmost quantity of the most fusible cinder; therefore, a blast furnace running on titaniferous ores, should not be fluxed by pure limestone, pure clay, or pure sand, but with ferruginous clay, ferruginous slate, or ferruginous limestone. These fluxes will dissolve titanic acid *at a low heat*. To get gray pig iron, the cinder must be abundant; to get white forge metal, but little flux is needed in comparison, the ore itself being wasted to form cinder. This *white iron with a large amount of carbon in it*, is just the metal from which German steel is manufactured. A high stack and a small hearth, like the Styrian furnaces, and ferruginous fluxes, are the best for titaniferous ores.

Osborne says (page 475), that Mr. Henderson writes him that the Norwegian ores are successfully used at Norton, England, on a plan invented by John Player, although they contain (by one anlaysis)

Titanic acid		40.95
Perox. iron	22.63	51.59
Protox. iron	28.96	
Magnesia	4.72	7.81
Alumina	2.11	
Silica	.42	
Protox. mang	.56	
		100.35

being smelted in small furnaces with 1000°F temperature of blast, 2 tons of coal to $2\frac{1}{2}$ tons of ore, 15 cwt. of limestone, 10 cwt. basalt rock.

"The iron becomes titanized, and is found to be exceedingly strong, and is used in Europe for armor plates, commanding *three times the price* of ordinary pig iron. The tensile strength of the resulting wrought iron, when puddled, is about $52\frac{1}{2}$ tons to the square inch. There is very little carbon in the pig-metal produced, and *being almost steel*, in puddling it requires but half the time of ordinary pig metal."

Muchat's Steel is a *titanic iron*, with the peculiarity of being sufficiently hard after being heated red hot and forged, not to require tempering,

but is comparatively brittle. Its color is not white, but has a tinge of straw color light brown.

The *lighter and looser varieties* of the Tuscarora ores have a lower per centage of iron in them, but will work more kindly in the blast-furnace. I had Mr. Frazer make me an analysis of a piece of outcrop ore from the Highfield plantation. It gave: Magnetic oxide, 44.53 [metallic iron, 32.25]. These varieties make equally good iron, and iron as well adapted to the manufacture of steel.

The hard and soft varieties of ore occur often within a few hundred yards of each other; as, for example, on the Widow McCristen's plantation (14-15 miles), where the soft outcrops are seen on the hill opposite the house, and the hard ore lies in large chunks on the hill, south of the swamp. I append Dr. Genth's analysis of specimens from the two places, made at my request:

1. Massive ore from Mrs. McCristen's Plantation. The analysis was so unexpected in its character, that Dr. Genth suspected some error, and repeated it, but with the same result. The small amount of titanium shows the varying nature of the deposits. The percentage of iron is also low for this kind of ore:

Iron........................33.97 p. c.
Titanium..................... 1.60 [=2.63 p. c. titanic acid.]
Ratio of Titanium to Iron............................1 : 21.24.

2. Soft micacious ore from the same locality. The high per centage of both iron and titanium in this ore was equally unexpected, and was very gratifying; for it will be seen from fig. 7, on page 17, that there is a total breadth of *ten feet* to this outcrop, in a space of twenty-seven. If any of the beds unite descending, the yield of ore will be great.

Iron........................43.47 p. c.
Titanium..................... 9.79 [=16.06 p. c. of titanic acid.]
Ratio of Titanium to Iron............................1 : 4.44.

It is made known by the Canadian geologists that the constituents of some of these primary ores are combined in such a way as to approximate the rock to a diorite, or green-stone trap. Now, such a rock is seen on several of the Company's leases; and especially on the Shaw, and other plantations two miles southeast of it. Sometimes the ore-bed itself become dioritic.

It will not be amiss to add other analysis of these Ores.

Ore Analysis, by F. A. Genth, in 1868.

Magnetic oxide	79.78	= iron...... 57.77
Titanic acid	12.08	
Oxide manganese	0.28	
Chrome oxide (trace of Vanadium)	0.32	
Silicic acid	0.75	
Alumina	4.62	
Magnesia	2.04	
Lime	0.13	

Ore Analysis, by J. B. Britton, June 3, 1868.

Iron (protoxide) iron........21.20 + (peroxide).......39.40		—60.60
Oxygen, with the iron in said 60.60		23.67
Mixed Sesquioxide, magnetic, &c		84.27
{ Titanic Acid		4.95
{ Containing other insoluble matter		3.25
Alumina		4.81
Lime		0.24
Moisture		1.66

No phosphorus, and a doubtful trace of sulphur.

NOTE.—I have changed the order and wording of this analysis, to suit the others for comparison.

Ore Analysis by C. Elton Buck, Wilmington, Del., Oct. 31, 1868.

Magnetic Oxide of iron	82.68	[—Iron 59.95]
Titanic Acid	8.72	
Ox. mang........0.42. Sesq. ox. chrom......0.40		0.82
Silica	1.89	
Alumina	3.93	
Lime	0.17	
Magnesia	1.36	

Another, June, 1869.

Magnet ox. iron	81.30	[—Iron 58.52]
Titanic Acid	12.32	
Ox. Mang. and Ox. Chromium, and Sulphur		traces.
Silica	1.04	
Alumina	3.87	
Lime	0.64	
Magnesia	0.49	
No phosphorus		
Moisture and loss	0.34	

Ore Analysis, by A. A. Fesquet, Nov. 12, 1868.

Metallic iron		60.41
Titanic acid	8.65	
Sesq. ox. Chrom..........0.83 } Sesq. ox. Manganese..........0.12 }	0.95	
Silica	1.50	
Alum	2.90	
Magnes	2.02	
Lime	0.75	

No trace of Sulphur.

A mere trace of Phosphorus.

Analysis made by pulverizing several hand specimens, and mixing them first, to obtain an average result.

Ore Analysis, by A. A. Fesquèt, July 6, 1869.

Specimen highly magnetic, and almost without moisture.

Metallic iron in combination with	57.30	79.14
Oxygen (calculated for peroxide)	21.84	
Titanic Acid		13.74
Silica	0.52	
Alumina	4.50	
Magnes	0.54	
Lime	0.72	
Sesq. Mang	0.69	

Trace of Chromium.

No sulphur ; no phosphorus.

Ochre Analysis, by A. Fesquèt, 1869.

Sesqui. ox. Iron	19.43	[containing met. iron 13.60]
Silica	34.12	
Alumina	33.21	
Water, &c., &c	13.24	

In this ochre, which forms large beds on the outcrops of the more ferruginous feldspathic rocks, one has a superior flux for any heavy burden ore, especially for a close titaniferous ore. The ochre must become a fluid double silicate, without robbing the ore, and will carry off the titanic acid in excess.

One of the constituent elements of the whole formation is Ochre, in beds of various sizes. What the exact geological relationship of these ochre beds to the magnetic ore-beds is, I do not know. But the ochre outcrops seem to be always in the immediate vicinity of the ore-beds. The largest exhibition of ochre which I saw is on the J. Somers Plantation on Brushy Creek. Here an ochre bed twenty feet thick rises, nearly vertical, out of a gully in a hillside covered with small pieces of fine compact ore.

Bar-iron Analysis, by A. A. Fesquèt, April 4, 1870.

"The samples of iron bars which you gave me to analyze have the following composition :

Metallic iron [includes what iron is combined with oxygen]	99.38
Insoluble calcined substances, [Silica, &c]	0.15
Carbon [and oxygen ?] [by difference]	0.47
Also, a trace of Titanic acid.	
	100.00

"I would judge from the nature of the samples, and former analysis, that the proportion 0.47 per cent. under head of Carbon, &c., is too considerable to be formed by Carbon alone, and comprises, very likely, carbon and oxygen. Therefore I would judge that part of the impurities is from oxide of iron, and the remainder from slag, which I have ascertained experimentally. In other words, the impurities are due to a highly basic slag, which cannot be expelled or squeezed out by the hammer and the rolls."

NOTE.—The above bars were rolled (from blooms of N. Carolina ore) by Jas. Rowland & Co., not cut and piled.

North Carolina Blooms made into Steel by the Martin's Process.

In January, 1871, Mr. A. A. Fesquét assisted at the conversion of ten tons of North Carolina blooms into steel, at Cooper & Hewitt's Works, Trenton, N. J.

The blooms were some of the first made at the Tuscarora Forge fires, rough and variable in size and quality, and weighing from 150 to 225 lbs.

Mr. Fesquét thus reports ;

The Siemens-Martin's Process consists in mixing steel scraps with pig iron. The Carbon of the pig iron reduces the iron oxidized by the flames; keeping watch, as it were, over it, and preventing the perpetually forming oxide of iron from forming a cinder with the silica of the furnace lining.

The charge being melted, it remains exposed to the flame until, and even after, all the carbon is burned off.

The exact moment is known by a series of samples being taken out, hammered and bent, hot.

If the samples be red short, Franklinite iron is added to restore enough carbon to remove the oxygen from the iron.

After one or two stirrings the metal is run into moulds.

The North Carolina blooms took the place of the steel scrap. The cast iron used was West Cumberland (English) pig, nearly free from sulphur and phosphorus, and with enough silicon and carbon to fit it for Bessemer use.

At the moment of complete decarburation a sample was taken. It was slightly red short. An analysis showed that the red-shortness was due to a minute proportion of oxide of iron and cinder, which had not been expelled because of the pasty condition of the decarburetted metal. Percentage of carbon less than 1-1000th part.

Franklinite was added; the metal became fluid, and was run into moulds.

The ingots were sound, and presented large crystals, of a clean gray color.

A sample from one was perfectly malleable, without a trace of hot or cold shortness, without a flaw, and homogeneous to all appearances. The large crystals were condensed under the hammer. The fracture was not jagged, and resembled that of cast steel of some degree of condensation and hardness.

In a word, *this* steel was malleable, homogeneous and tough, like the best steel produced in any other way.

Tried at the forge fire (by the same workman), it seemed to bear more heat for welding and hardening than will the ordinary steel (with a corresponding proportion of carbon).

Less carbon is necessary in the case of titanium steel than in the case of common steel, to arrive at the same hardness.

In the rolls, this steel manifested no difficulties, according to the testimony of Mr. Slade of the Trenton Works.

Waste: Three operations, 14,152 lbs. of metal in all; waste, 13.5 per cent.,

exceeding somewhat the waste when steel scraps are used; for the cinder in the blooms has to be purged off in the process, and secondly, the almost purely metallic titaniferous bloom iron is much harder to melt than scrap steel; is longer exposed therefore to the flame, and therefore wastes more. By adding pig metal this evil will find a remedy.

The peculiar qualities of this steel will no doubt be intensified when its own titaniferous pig metal is used with its titaniferous forge blooms.

A dose of Franklinite may yet be necessary. Mr. Fesquét thinks it acts by giving up carbon. He suggests, however, that possibly it acts through manganese; but as nearly all the manganese goes off in the slag, he thinks its peculiar use is to keep the cinder fluid, and taking the iron's place in the cinder.

Stated Meeting, July 21, 1871.

Present, three members.

MR. CHASE in the Chair. Secretary, MR. LESLEY.

A photograph of Dr. O. Seidenstricker was received for the Album.

Letters of envoy were received from the Senkenburg Society, at Frankfort, the I. Akad. Vienna, and the Society at Riga.

Letters of acknowledgment were received from Dr. Bunge, of Greiswald; Herr Tunner, of Leoben; Dr. Rokitansky; the Zool. Bot. Soc., Vienna; Munich Observatory, and Chicago Academy.

A letter was read from Mr. Putnam, of Salem, the consideration of which was postponed.

Donations for the Library were received from the R. S., Tasmania; I. A., Vienna; Z. B. S., Vienna; Senk. S., Frankfort; R. Danish S.; R. Com. Geol., Italy; Capt. Settimanni; School of Mines, Paris; R. Ast., R. Geogr. and Chem. SS., London; Nature; San Fernando Observatory; Essex Institute; Mass. Hist. S., Am. Antiq. S., Camb. Mus. Com. Zool., J. H. Trumbull, Sill. Jour., Mrs. Willard, N. Y. Lyceum, Frank. Inst., Acad. N. S., Coll. Pharmacy, Med. News, Dr. Rushenberger, Isaac Lea, Peabody Inst., and Secretary Robeson, of Washington.

The death of Mr. Eugenius Nulty, at Philadelphia, on the 3d inst., aged about 83 years, was announced by the Secretary.

Mr. Chase communicated a Note on the Pluvial Indications of the Metonic and Sun-spot Cycles.

Pending nominations 677 and 678 were read and balloted for, and the following named gentlemen declared duly elected members of the Society:

Prof. Cleveland Abbe, Signal Ser., War Dep't, Washington.

Mr. Benj. Chew Tilghman, of Philadelphia.

And the meeting was adjourned.

Stated Meeting, May 19,* 1871

Present 13 members.

Vice-President, MR. FRALEY, in the Chair.

Letters accepting membership were received from Rev. Dr. James McCosh, dated Princeton, N. J., May 4th, 1871; Prof. E. B. Andrews, dated Columbus, Ohio, May 4, 1871, and Dr. T. A. P. Barnard, dated Columbia College, N. Y., May 5, 1871.

A Photograph for the Album was received from Prof. Roehrig, of Cornell University.

Letters acknowledging the receipt of the Society's Publications were received from the R. Bavarian Academy, (27, 65 to 67; 75, 76, 81, 82); the Society of P. & N. H. at Geneva, (XIII, 3, 78 to 83); the Physical Society at Berlin, (XIII, 3; 81, 82,) the Boston N. H. S., (XIII, 3, XIV, 1, 81, 82, 83, 84, 85,) and the Library of Congress (XIV, 1).

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*The report of this meeting has been inadvertantly misplaced.

Letters of envoy were received from the Physical Society of Berlin, and Dr. C. Naumann of Leipsig.

A letter was received from Mr. W. Barker, Engraver to the U. S. Mint, presenting to the Cabinet of the Society, a medal of David Rittenhouse, after a bust in the possession of the Society.

Donations for the Library were received from the Geological Institute and Authropological Society at Vienna, the Physical Society at Berlin, Dr. Naumann, the Bavarian Academy, the Zoological Garden at Frankford, the Natural History Society at Geneva, the London Meteorological Office and Board of Trade, and Editors of Nature, the Essex Institute, Boston Natural History Society, American Oriental Society, Franklin Institute, Medical News, Wilmington Institute, Mr. G. W. Shaffer of Savannah, and Dr. Newberry.

The death of Sir John F. W. Herschel, on the 12th inst., aged 79, was announced by the Secretary.

A specimen of the Jenny Jump variegated marble of New Jersey, was laid upon the table, and its geological character was discussed by several of the members present.

The attention of the members was called to Herr Lauth's recent memoir on the Gold Mine Map Papyrus of the age of Seti I., and its interesting points described by the Secretary.

New nominations Nos. 677 and 678 were read.

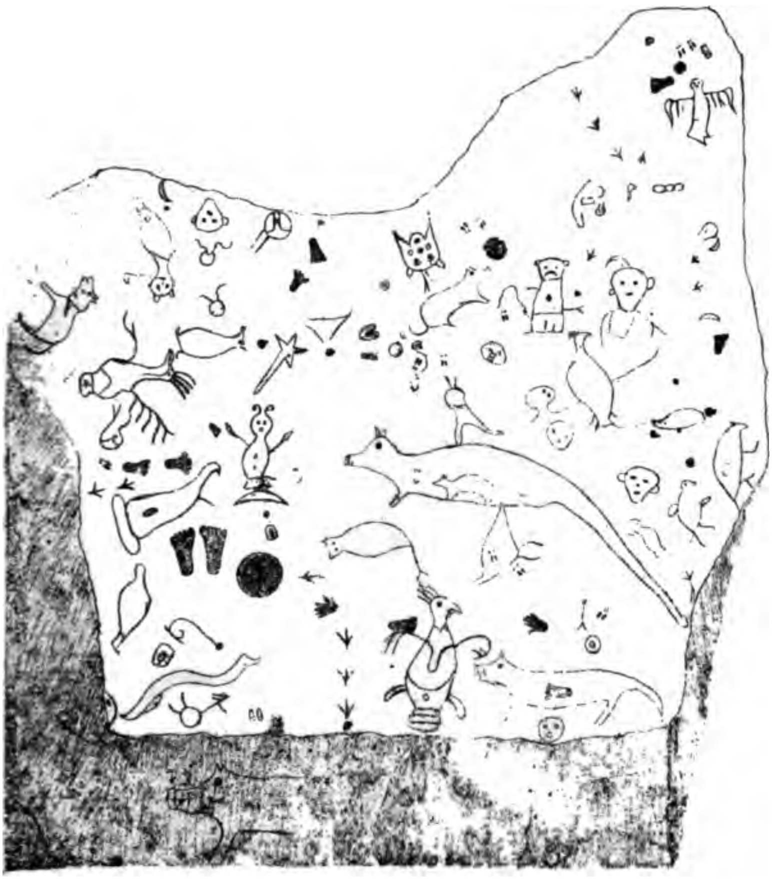
On motion of Mr. Chase, the Meteorological Office at Washington was ordered to be placed on the list of correspondents to receive the Proceedings.

On motion of Mr. Lesley, the American Institute of Civil Engineers was placed on the list of correspondents to receive a set of the Proceedings.

On motion, the thanks of the Society were tendered to Mr. Barber, for his beautiful present.

And the meeting was adjourned.

Indian Sculptures on a rock in South Western Pennsylvania.

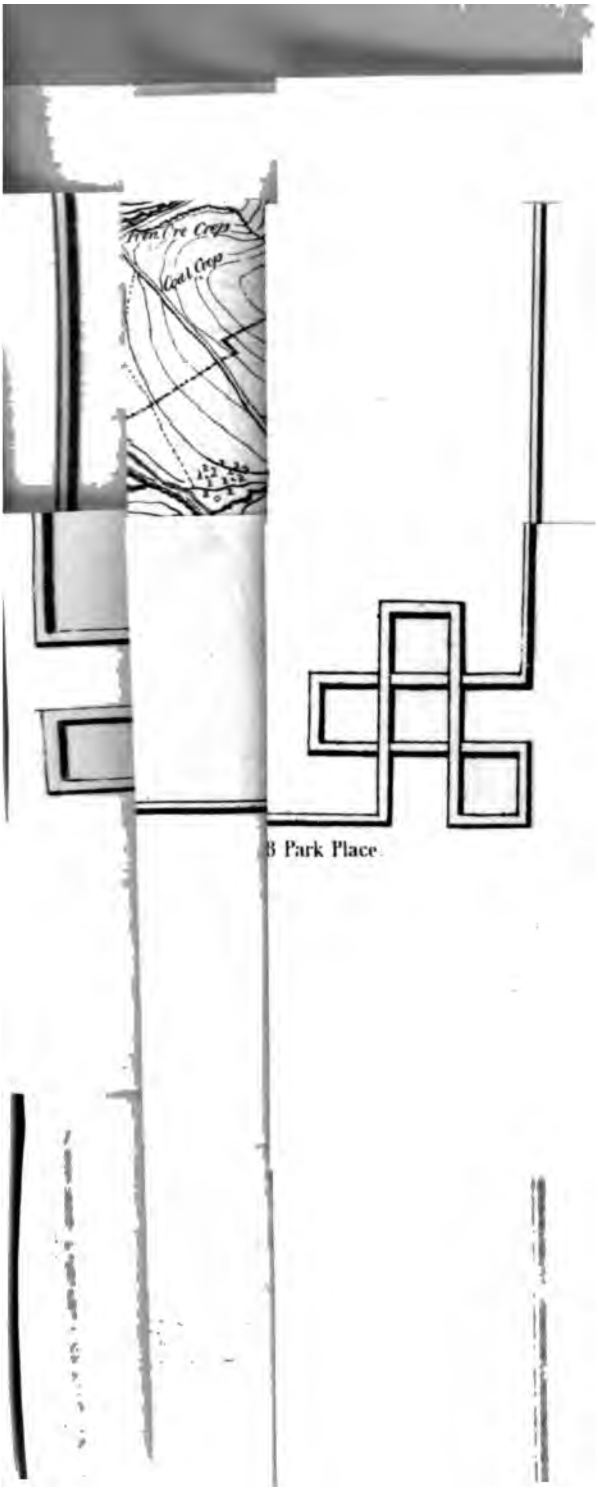


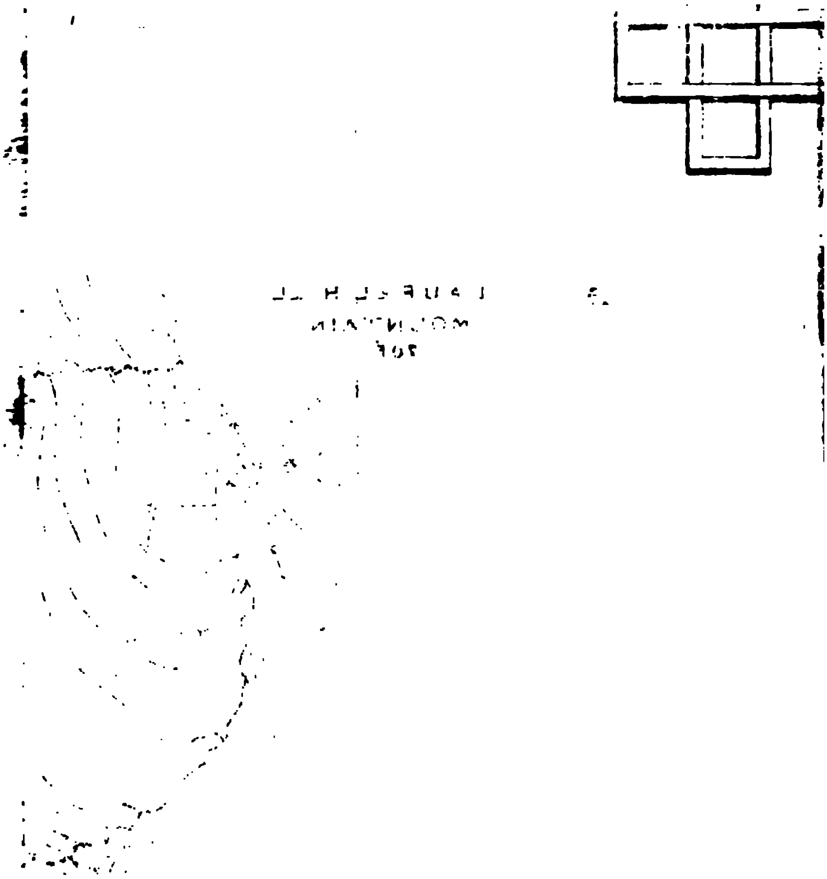
H. Faber del. et

EXPLANATION OF PLATES I. AND II.

Fig. 1. Posterior surface of right Humerus.
" 2. Anterior surface of left Humerus.
" 3. Section of left Humerus.
" 4. " " natural size.
" 5. Section of left Femur.
" 6. Anterior surface of right Femur.
" 7. Posterior surface of right Femur. The notch about the middle is where a slice was removed for microscopic preparations.
Fig. 8. Section of left Radius.
" 9. Posterior surface of left Radius.
" 10. Posterior surface of right Radius.
" 11. Anterior surface of right Radius.
" 12. Section of left Ilium.
" 13. End of right Clavicle.
" 14. Posterior surface of right Ulna.
" 15. Anterior surface of right Ulna.
" 16. Section of left Ulna.
" 17. " " natural size.
" 18. Posterior surface of right Fibula.
" 19. Posterior surface of left Tibia..
" 20. Anterior surface of right Tibia.
" 21. Section of Phalanx natural size.
" 22. Section of healthy Phalanx natural size inserted for comparison.
Fig. 23. Vertebral end of spine of left Scapula.
" 24. Anterior surface of carpal end of right Radius enlarged.

N. B. All the drawings except where noted are on a scale of $\frac{1}{2}$ the natural size.


Iron Ore Crop
Coal Crop
Park Place



Cartes de Visite of members for the Album of the Society, will be received with acknowledgments.

Dr Leidy.
1302 Filbert.

PROCEEDINGS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY.

HELD AT PHILADELPHIA, FOR PROMOTING USEFUL KNOWLEDGE.

VOL. XII. 2. JULY TO DECEMBER, 1871. No. 87.

CONTENTS.

NOTE.—As inquiries have been received respecting Plates Nos. 1, 6, 7 and 8, of Vol. XI., Proceedings of the American Philosophical Society, Correspondents and members of the Society are hereby informed, that the plates of that Volume were irregularly numbered, and that no plates corresponding to the above mentioned numbers were printed.

Stated Meeting, Aug. 18th, 1871.

Present, two members.

Secretary, MR. TREGO, in the chair.

Photographs were received from Prof. Max Müller, of Oxford, England, and from M. Stanislaus Julien, Membre de l' Institut, Paris.

A letter accepting membership was received from Prof. Cleveland Abbe, dated Washington, D. C., July 24, 1871.

Letters of acknowledgment were received from the New York City University (86).

Donations for the library were received from the Hungarian Academy; Herr K. Magey; the Society at Moscow; the Russian Academy; Prussian Academy; Geological Society and Botanical Society of Berlin; the Societies at Gottingen and Bremen; the Geographical Society at Paris; the London Astronomical Society and Meteorological Bureau; Editors of Nature, Cornwell Polytechnical Society; Peabody Museum; Essex Institute; Medical News; and U.S. Department of Engineers at Washington.

The death of Mr. Sidney G. Fisher, a member of the Society, at his residence near Rising Sun, Philadelphia, July 25th, 1871, in the 63d year of his age. was announced.

Mr. Chase presented some tables of daily Rainfalls at the Observatorio do Infante Don Luiz, Lisbon, from 1855 to 1870, with some comparisons, indicating an opposition between the lunar daily rains at Lisbon and Philadelphia, similar to the one he had pointed out as existing between the solar daily rains at the same stations.

And the meeting was adjourned.

Stated Meeting Sept. 15th, 1871.

Present, two members.

Vice-President, MR. FRALEY, in the chair.

A letter accepting membership was received from Mr. B. C. Tilghman, dated Philadelphia, Aug 1871.

Photographs for the Album were received from Prof. Geo.

H. Cook and Col. M. J. Cohen, the latter sending a carte de visite of the late Dr. Joseph I. Cohen, of Baltimore.

Letters of envoi were received from the Central Observatory of Russia, and the office of the Chief of the U. S. Engineers at Washington.

Letters acknowledging the receipt of Publications of the Society were received from the Russian Central Observatory; the Leeds P. & L. Society, August 24 (xiv. i. 83, 84, 85,); the Society of Antiquaries, London,. August 26 (xiv. i. 83, 85); the Society of Arts at Batavia, May 31, 1869 (xiii. 2, Proc. July, 1865); the Radcliffe Observatory, August 10th, (83, 84, 85); the Geological Committee of Italy, at Florence, August 12 (Proc. vol. xi. 2); the Glasgow Philosophical Society, August 10th (83, 84, 85); the Regents of the New York University, August 7 (Proc. vol. x, xi); the Boston Public Library, August 23 (86); Rhode Island Society for the encouragement of Domestic Industry (86); Georgia Historical Society, Savannah, August 24 (86); Wisconsin Historical Society, Madison, August 25 (86); New York Historical Society, New York, September 1 (86); New Jersey Historical Society, Newark, Sept. 1 (86); Essex Institute, Salem, Mass., Sept. 2, 1871 (86).

Donations for the Library were received from the Academies at St. Petersburg, Berlin and Bruxelles; the Societies at Batavia and Riga; Herr Von Frauenfield, of Vienna; the Geological Committee of Italy; Geographical Society in Paris; Zoological Society and Society of Antiquarians in London; London Nature; the Essex Institute; Boston Natural History Society; R. I. Society for the Encouragement of Domestic Industry, at Providence; the American Journal of Science; Mr. J. H. Trumbull; the American Chemist; President Barnard of Columbia College; the Franklin Institute; American Journal Medical Science; Journal of Pharmacy; Penn Monthly; and Dr. Richard J. Dunglison, of Philadelphia.

A communication for the Proceedings was received, entitled "On the Formation and Primitive Structure of the Solar System," by Professor Daniel Kirkwood, of Bloomington, Indiana.

And the meeting was adjourned.

On the Formation and Primitive Structure of the Solar System.

By Professor Daniel Kirkwood.

(*Read before the American Philosophical Society, Oct.* 6, 1871.)

The development of any branch of science is generally a slow and gradual process. The obvious truths which suggested to Laplace his celebrated hypothesis of the solar system had been for ages well known to astronomers; but, as in the case of the earlier geological observations, they had been regarded, without any just reason, as *ultimate facts*. So now we have numerous results of observation in regard to the rings of Saturn, the zone of asteroids, the relative distances of the planets, &c., the study of which, it is believed, may lead to new and important discoveries. "These hieroglyphics older than the Nile," pointing back to the epochs at which the planets were born, will doubtless in the future be more or less clearly deciphered, and the ancient history of the solar system at least partially developed.

It is a very remarkable fact in regard to the systems of both primary and secondary planets that the periods, without any exception, have very simple relations of approximate commensurability. This truth, though obvious on mere inspection, seems not to have attracted the special notice of astronomers, as no attempt had been made, previous to that of the writer, to assign its physical cause. A general view of these approximations is presented in the following tables, where the periods of the primary planets, Mercury, Venus, &c., are represented by P^{I}, P^{II}, &c., and those of the satellites by p^{I}, p^{II}, &c.

I.

The Primary System.

$\frac{1}{2}P^{VIII}$	—82.37 years	—P^{VII}	—1.65 y.
$\frac{1}{3}P^{VII}$	=28.01	"	—P^{VI}	—1.45
$\frac{2}{5}P^{VI}$	—11.78	"	—P^{V}	—0.08
$\frac{1}{6}P^{V}$	— 1.97	"	—P^{IV}	+0.09
$\frac{1}{12}P^{V}$	—0.988	"	—P^{III}	—0.012
$\frac{2}{3}P^{III}$	—0.667	"	—P^{II}	-0.052
$\frac{2}{5}P^{II}$	—0.246	"	—P^{I}	—0.005

II.

The Jovian System.

$^{3}_{\cdot}p^{IV}$	—p^{III}	—	3^{m}	9 ^{s}
$\frac{1}{2}p^{III}$	—p^{II}	+	36	40
$\frac{1}{2}p^{II}$	—p^{I}	+	9	45

III.

The Saturnian System.

$\frac{2}{7}p^{VIII} - p^{VII}$	$+$ (?)				
$\frac{1}{5}p^{VIII} - p^{VI}$	$-$	1^h	54^m	41^s	
$\frac{2}{7}p^{VI} - p^{V}$	$+$	0	55	13	
$\frac{1}{6}p^{VI} - p^{IV}$	$-$	1	54	15	
$\frac{1}{2}p^{IV} - p^{II}$	$-$	0	2	33	
$\frac{1}{2}p^{III} - p^{I}$	$+$	0	1	50	

IV.

The Uranian System.

$\frac{2}{3}p^{IV} - p^{III}$	$+$	6^h
$\frac{1}{2}p^{III} - p^{II}$	$+$	5
$\frac{3}{5}p^{II} - p^{I}$	$-$	1

It is infinitely improbable that all these coincidences should be purely accidental. Their physical cause is a legitimate object of research, and the writer is vain enough to believe that he has suggested the true one.* Before proceeding with our discussion, however, it may be proper to indicate such modifications of the nebular hypothesis as seem to be demanded by recent discoveries.

The view generally received in regard to the formation of the solar system has been that equatorial rings were abandoned *only* in the vicinity of the present planetary orbits. As the writer has elsewhere observed, however, "it seems highly probable that, after first reaching the point at which gravity was counterbalanced by the centrifugal force arising from the rotation of the contracting spheroid, a continuous succession of narrow rings would be thrown off in close proximity to each other, and revolving in different periods according to Kepler's third law." But in this matter we are not left to mere speculation. The zone of minor planets has evidently not been produced by a single annulus, all the parts of which had, at first, nearly equal velocities. On the contrary, it must have resulted from an almost continuous abandonment of narrow rings, from the exterior limit at the mean distance 3.50, down to the interior, at 2.20. The rings of Saturn, moreover, afford a similar index to the process of planetary formation.

Let us assume, then, the existence of a central mass S, with a ring R, and an exterior planet P. The particles of the ring having different distances from the centre of motion will move with different velocities. Let

*Met. Astr., Ch. XIII., and Monthly Notices of the R. A. S., vol. XXIX.

S p be the distance at which a planetary molecule would revolve in one half the period of the planet P. The disturbing effect of P will render the orbit of p more and more eccentric. The particle, therefore, must be brought into contact, either in aphelion or perihelion, with other parts of the ring, thus forming a planetary nucleus at such distance that its period would be *nearly* one-half that of the exterior planet. Similar reasoning will apply to the distances at which the ratio of the periods would be $\frac{1}{3}$, $\frac{2}{5}$, or any simple relation of commensurability. We have thus an extremely simple explanation of the facts embodied in the preceding tables. Should it be objected that this theory fails to account for the formation of the most remote planet, it may be answered that the first separation of matter from the condensing nebula probably occurred before the mass had assumed a symmetrical form. The successive ratios of the periods from Neptune to Jupiter are $\frac{1}{2}$, $\frac{1}{3}$ and $\frac{2}{5}$. With Jupiter, "the giant of the solar system," the process of planet formation seems to have culminated; the mass of this stupendous globe being nearly three times greater than that of all other members of the solar family united. But why have we no planet of any considerable magnitude whose period is one-half, one-third, or two-fifths that of Jupiter? It may be answered, in the first place, that the matter of asteroid ring was so extremely rare that the intersection of orbits failed to produce large planetary nuclei. The question recurs, however, whence the *small mass* of the ring immediately interior to the *largest* member of the system? The circumstances of the primitive asteroid-ring were different from those of any other. As its successive portions were thrown off at the equator of the solar nebula they would be liable to great perturbations by Jupiter. The perihelion distance of portions of the zone might thus become less than the equatorial radius of the spheroid by which they had been abandoned. A considerable proportion of the matter originally separated may have been thus re-united to the parent mass.*

The writer has shown however, that in the distribution of the mean distances of the asteroids, we have indications of an order similar to that of the exterior planets. This fact is rendered still more conspicuous by recent discoveries. The distances at which the periods of asteroids would be one-half, two-fifths, and one-third that of Jupiter, are respectively, 3.2776, 2.8245, and 2.5012. Between the mean distances 3.22 and 3.32 no asteroid has yet been discovered; while between 3.12 and 3.22 there are no less than 12. Between 2.78 and 2.88, the interval containing the distance at which five times the period of a planet would be equal to twice that of Jupiter, only two have been detected; while in the equal space immediately interior, from 2.68 to 2.78, there are 21. Finally, between 2.45 and 2.55, the space in the middle of which an asteroid's period would be one-third that of Jupiter, the number of known asteroids is 4; while in the equal space immediately interior there are 20, and in that exterior, 15. These facts are certainly very remarkable, and deserve the earnest consideration of astronomers.

*See Proc. Am. Phil. Soc., Aug. 19, 1870.

The preceding table of the primary system seems to indicate the dependence of the periods of Mars and the earth on the powerful mass of Jupiter. The relations expressed between the periods of the earth, Venus, and Mercury are sufficiently obvious. It is worthy of remark that the *original* distances of the exterior planets have been, in all probability, sensibly diminished. While the solar nebula was undergoing the process of condensation all cometary and meteoric matter attracted towards its centre, would, if the perihelion distance were considerably less than the radius of the nebula, become incorporated with the central body. This growth of the solar mass would produce a shortening of the periodic times of all planets previously formed.

The approximations to commensurability in the secondary systems are still more striking, and must produce the impression in every inquiring mind that they are not without their physical significance.

The rings of Saturn formerly supposed to be solid and continuous, are now regarded as consisting of an indefinite number of extremely small satellites. They are, in short, a compact cluster of secondary asteroids, analogous to the primary zone between Mars and Jupiter. In the latter, it is true, a large proportion of the primitive matter has collected in distinct, planetary masses; while a similar result has been prevented in the Saturnian rings by their proximity to the central body. In one respect, however, we observe a striking correspondence. It has been shown that several positions occur in the asteroid zone where planetary periods would have simple relations of commensurability with the period of Jupiter, and that portions of the original ring occupying these positions would be liable to great disturbance. Now, the ring of Saturn is evidently subject to like perturbation by the nearest satellites. Hence gaps or chasms, analogous to those in the zone of asteroids, ought also to be found in the secondary ring. It has accordingly been noticed that Cassini's, or rather Ball's division occurs precisely where the periods of satellites would be commensurable with those of the four members of the system immediately exterior.*

But astronomers have sometimes seen the ring of Saturn apparently separated by several black lines into concentric annuli. At other times, however, no such divisions could be detected. The fact, therefore, of the permanence of these gaps is extremely doubtful, except in the case of a division of the exterior bright ring. This has been frequently seen by eminent astronomers; and it is probable, though not absolutely certain, that it is never entirely closed. Most observers agree in placing it outside of the middle of the exterior ring. Let us now inquire whether any simple relation of commensurability obtains between the periods of satellites revolving at the distance of this outermost gap, and those of Mimas, Enceladus, Tethys, and Dione.

$\frac{4}{7}$ of the period of Mimas	=	$12^h\ 56^m$
$\frac{2}{7}$ " Tethys	=	12 57

* *Meteoric Astronomy*, Chap. XII.

$\frac{1}{5}$	"	Dione	— 13	8
$\frac{2}{5}$	"	Enceladus	— 13	9

The interior radius of the outer ring	= 1.9963
The radius of a circle bisecting the outer ring	= 2.1209
The distance of a satellite whose period is $12^h\ 56^m$	= 2.1473
The distance of a satellite whose period is $13^h\ 9^m$	= 2.1510
The exterior radius of the outer ring	= 2.2456

It is thus seen that just beyond the middle of the outer ring, where the division is actually found, another zone occurs in which the periodic times of satellites would be commensurable with those of Mimas, Enceladus, Tethys and Dione.

The FACTS detailed in the preceding pages are unquestionable. In regard to the proposed *explanation* of these facts the writer would speak with becoming caution. In his humble attempt to reduce a large class of isolated truths to the domain of law some important considerations may have been overlooked. Be this as it may, he indulges the hope that abler astronomers may deem the enquiry not unworthy their researches.

Stated Meeting, Oct. 6th., 1871.

Present, fifteen members.

Vice President, Mr. FRALEY, in the chair.

A photograph for the Album was received from Professor E. N. Horsford, dated Cambridge, Massachusetts, October 29.

Letters of acknowledgment were read from the London Meteorological Office, September 22 (83, 84, 85); and the Buffalo Society of Natural Sciences, December 1, 1870 (XI Pro).

Letters of envoi were received from the Natural History and Historical Union of Donauerschingen, September 15, and the United States Secretary of the Interior, Washington, D. C., September 15, 1871.

A recent letter from Mr. Carlier to Mr Durand, was read by Mr. Price, who offered a Resolution, which was adopted, authorizing the presiding officer of the meeting to execute

a Power of Attorney to M. Carlier, of Paris, to receive moneys on account of the Michaux Legacy.

Donations for the Library were received from Doctor Zenaro, of Constantinople, the Union at Donauerschingen, the Prussian and Belgian Academies, Geographical Society at Paris, Annales des Mines, Revue Politique, the Meteorological Office and Nature of London, the Montreal Natural History Society, the American Academy, Natural History Society, and Old and New of Boston; Mr. Edmund Quincy, of Dedham, Massachusetts, the American Journal of Arts and Sciences; Doctor Squibb, of New York, the Franklin Institute, College of Pharmacy, and Penn Monthly, of Philadelphia, the Census Bureau at Washington, and the Historical Society of Georgia at Savannah.

An obituary notice of the late Doctor Rhoads, of Philadelphia, was read by Doctor Henry Hartshorne.

Professor Kirkwood's paper on the Origin of the Solar System, was read by the Secretary.

A letter from Professor Cope to the Secretary, on the Reptile and Fish remains in the State Museum of Kansas, was read by the Secretary.

Mr. Baird communicated his views on the cause of the decline of vegetable vitality in fruit trees, dating from the year 1860.

Mr. Lesley read a note on some supposed Egyptian letters, in the Dolmen of Manelud, in Brittany.

New nomination, No. 679 was read, and the meeting was adjourned.

Note of some Cretaceous Vertebrata in the State Agricultural College of Kansas, U. S. A.

By Edward D. Cope.

Manhattan, Kansas, 1871.

My dear Prof. Lesley:

A visit to the State Agricultural College of Kansas at Manhattan, has enabled me to examine the cretaceous vertebrata contained in its collection. Professor B. F. Mudge, already well known by his interesting discoveries among the *Pythonomorph* reptiles and *Saurodont* Fishes, has

added to his collections by an excursion in the neighborhood of Fort Wallace, during the present summer. By his permission I have made an examination of these fossils, and find them to be of much interest. They consist of seven species of *Pythonomorpha*, and three of *Saurodontidæ*. The following are approximate or exact determinations of them.

PYTHONOMORPHA.

MOSASAURUS quite near to *M. depressus*, Cope, from New Jersey.

LIODON DYSPELOR, Cope, probably. The first time that this gigantic reptile has been discovered in Kansas.

LIODON; a large species near to *L. proriger*, Cope. It is represented by dorsal, lumbar, and caudal vertebræ, by ribs, and by bones of the extremities. The humerus is a remarkable bone having the outline of that of *Clidastes propython*, Cope, but is very much stouter, the antero-posterior dimensions of the proximal extremity being greatly enlarged. The long diameters of the two extremities are in fact nearly at right angles, instead of in the same plane, and the outline of the proximal is subtriangular, one of the angles being prolonged into a strong deltoid crest on the outer face of the bone, which extends half its length. The inner or posterior distal angle is much produced, while the distal extremity is a flat slightly curved diamond-shaped surface. The radius is as broad as long and three quarters of a disc. The phalanges are stout, thick and depressed, thus differing much from those of *Liodon ictericus*. A bone which I cannot assign to any other position than that of femur* has a peculiar form. It is a stout bone but more slender than the humerus. The shaft is contracted and subtrilateral in section. The extremities are flattened, expanded in directions transverse to each other, the proximal having, however, a lesser expansion, in the plane of the distal end. The former has, threrefore, the form of an equilateral spherical triangle, the apex enclosing a lateral fossa and representing probably the great trochanter. The distal extremity is a transverse and convex oval.

	M.
Length humerus	0.10
Proximal diameter do.	.095
Length femur	.08
Proximal diameter do.	.065
Median "	.035
Length centrum dorsal vertebra without ball	.061
Transverse diameter cup	.06
Vertical "	.053

LIODON LATISPINUS, Cope, sp. nov.

This is a large species, nearly equalling the *L. mitchillii* in its dimensions, that is forty or fifty feet in length. The remains representing it consist of seven cervical and dorsal vertebræ, five of them being continuous and enclosed in a clay concretion.

* Prof. O. C. Marsh has discovered the posterior limbs in this genus and *Clidastes* but has as yet published no description of them. See Sillim. Journ. 1871, p. 418.

These display the elongate character seen in *L. laevis*, etc., but the articular surfaces are transversely oval, thus resembling the *L. ictericus*. They are less depressed than in *L. perlatus* and *L. dyspelor*. The cup and ball of the penultimate cervical rise a little more transverse than those of the fourth dorsal. The last cervical is strongly keeled on the middle line below, and with a short obtuse hypopophysis marking the beginning of the posterior third of the length ; the median line of the first dorsal has an obtuse ridge. There is no keel on the fourth dorsal. The diapophyses on the last two cervical and three first dorsal vertebræ have great vertical extent ; the articular surface for the rib is not bent at right angles on the last cervical. Neural arches and spines are well preserved in most of the specimens. There is no trace of zygantrum. The neural spines are flat, and have considerable antero-posterior extent on cervical as well as dorsal vertebræ, and are truncate above. The first dorsal has a long strong rib.

	M.
Transverse diameter cup penultimate cervical vertebra..........	.051
Vertical diameter of same....	.041
Length centrum fourth dorsal, without ball.....................	.072
Vertical diameter ball..	.0455
Transverse do	.0555
Elevation front margin neural spine penultimate cervical........	.088
Antero-posterior diameter do do do	.05

There are smooth bands around the balls and the surfaces of the centra are striate to these.

The depressed cups of the cervicals and anterior dorsals distinguish this species from the *L. validus*, *L. proriger* and *L. mudgii*. The same elements are much larger and more elongate than in *L. ictericus*.

LIODON, sp. near *ictericus*, Cope.

Represented in Prof. Mudge's collection by portions of cranium including jaws and quadrate bones, etc., with cervical and dorsal vertebræ.

CLIDASTES WYMANII, Marsh, probably.

CLIDASTES CINERIARUM, Cope. Dorsal and cervical vertebræ.

SAURODONTIDÆ.

ICHTHYODECTES, nr. *ctenodon*, Cope.

ANOGMIUS CONTRACTUS, gen. et sp. nov. ? Saurodontidarum.

Represented by a large series of vertebræ and portions of fins of an individual of perhaps four feet in length. The characters of the vertebræ are those of *Ichthyodectes* in part, i. e. they lack the lateral grooves, but they resemble those of *Saurocephalus* in having the basal elements of the neural and haemal elements inserted by gomphosis and not coössified with the centrum. Specifically, the centra are relatively longer than in *I. ctenodon*, and more as in the shorter forms of *Saurocephalus*, as *S. prognathus*, which species the present one approaches in size.

SAUROCEPHALUS, nr. *prognathus*, Cope.

Obituary Notice of Edward Rhoads, M. D.

BY HENRY HARTSHORNE, M. D.

(*Read before the American Philosophical Society, Phila. Oct.* 6, 1871.)

Of those recently deceased, members of a profession which has contributed a large share of workers to the different fields of biological science, few have given greater promise, and not many among us have attained to better performance in a short career, than Edward Rhoads. Unfavorable for the full appreciation of his work, except by those with whom he was closely associated, has been the fact that much of it has been unrecorded; being the daily labor of the practitioner and teacher of medicine. But it is fitting that this Society, whose pursuits and membership are not narrowly limited, should at least briefly record its recognition of such high ability and character.

Edward Rhoads was born in Philadelphia, September 29, 1841. After a good preliminary training, in which an early love of natural science displayed itself, he entered Haverford College in 1855; and was graduated there, at the head of his class, in 1859. The rural situation of the college afforded him an opportunity for the study of Botany, in which he became well versed while a sudent. Shortly after leaving college, an attack of rheumatic fever, involving the heart, began those inroads upon his constitution, the repetition of which afterwards abridged his life. In the fall of 1860 he commenced the study of medicine, and obtained the degree of Doctor of Medicine at the University of Pennsylvania, in 1863. He was then elected, after a competitive examination, Resident Physician in the Philadelphia Hospital, West Philadelphia. This was followed, in 1864, by his appointment as Resident Physician in the Pennsylvania Hospital. In the midst of his arduous duties there, performed with distinguished success and with satisfaction to all, he was again affected with articular rheumatism, which renewed seriously the disorganizing disease of his heart.

On recovering from this attack, he visited Europe, in 1865, being absent eight months. In 1866, he was appointed Visiting Physician to the Philadelphia Hospital; where his professional talent, enthusiasm and knowledge, and his capacity as a clinical teacher, found free scope for development and utility. He was at the same time assiduously engaged in private medical teaching, as an examiner in connection with the courses of the University of Pennsylvania, and in giving lectures upon medical chemistry and connected subjects. In 1870 the faculty of the University appointed him its lecturer on Physical Diagnosis. His first course of lectures was interrupted by illness, which prevented his ever resuming the duties of a public instructor.

In the same year, a number of gentlemen proposing to establish a new medical journal,—The Philadelphia Medical Times,—its editorship was unanimously offered to Dr. Rhoads. This duty, which enlisted all his zeal, and would have illustrated admirably his professional learning and

tact, he was obliged to forego on account of his failure in health, which, after great suffering for several months, ended his life January 15, 1871.

In private practice, Dr. Rhoads was rapidly gaining the confidence and success which his skill and acquirement deserved; as well as the warm and grateful attachment of many families,—which remains in commemoration of his virtues, more faithful than any eulogy, and more enduring than any monument. He was elected to membership, besides the Philosophical Society, in the Philadelphia College of Physicians, of which he was Recording Secretary, the Academy of Natural Sciences, and the Pathological Society. To the proceedings of the latter he contributed a number of papers. He wrote for the American Journal of the Medical Sciences several reviews, showing a quick critical apprehension, a large acquaintance with medical science and literature, and an excellent command of language. He assisted Dr. J. F. Meigs in the preparation of an elaborate paper, published in the first volume of the Pennsylvania Hospital Reports, 1868, on "The Morphological Changes of the Blood in Malarial Fever." With Dr. W. Pepper, he contributed to the same volume the results of an extended inquiry into the "Fluorescence of the Tissues of the Human Body, especially in connection with Malarial disease and the action of Quinia." The scientific spirit which animated all his professional labors, and which he brought to the investigation of the great problems of Pathology and therapeutics, thus elevating the vocation of the physician far above routine, was well exemplified in this paper. Its preparation was suggested by the remarkable observation of Bence Jones, by whom a fluorescence resembling closely that of a solution of quinine was found to occur in solutions of the tissues of animals which had taken none of that substance. A peculiar fluorescent organic principle was here inferred to be a normal constituent of the animal body; and to this Bence Jones applied the name of "Animal Quinoidine." It was not an irrational hypothesis, that the systemic effects of the malarial poison may be attended by an injurious deficiency of this material; and that quinine, or the other extractives of Peruvian bark, may be remedial for the disease, by supplying the system with its equivalent.

Drs. Rhoads and Pepper undertook first, to ascertain whether, by chemical and spectroscopic analysis, there could be shown to be a marked diminution in the amount of animal quinoidine in the body under the influence of malarial disease. They also gave attention to the effect upon the animal fluorescence produced by the treatment of the attack by sulphate of cinchonia. The interesting result was arrived at by a series of careful and exact determinations, that there is, uniformly, a close connection between malarial disease and the diminution of "animal quinoidine;" and that this connection is apparent, not only in the presence of a fully developed paroxysm of fever, but also when the system is more insidiously, though often very seriously, affected by the morbid cause.

The same exact inquiry into evidence, with the aim to discover and establish truth, was applied by Dr. Rhoads in his consideration, both theo-

retical and practical, of the highest topics, not only of science, but of philosophy. Contented to accept no truth upon the evidence of mere tradition or human authority, his opinions upon religious subjects, being those held by the Society of Friends of which he was a member, were the result of deliberate and strong conviction. His fine critical faculty was brought to bear upon the recent Biblical and anti-Biblical controversies, represented, upon the one side, in different modes, by Strauss, Bauer, Comte, Renan and Buckle. In several essays, prepared for special occasions, only one of which, however, has been published, he displayed a calm mastery of these topics, an amount of knowledge and force of argument, such as might be looked for rather in a professed theologian than in an active member of the medical profession.

With all who knew Dr. Edward Rhoads, however, his intellectual endowments, though great, were always perceived to be subordinated to moral qualities more rare and admirable. From early youth, purity of life, unselfishness, refinement and elevation of mind, were his marked characteristics. Few examples so spotless are met with in any profession or sphere of life. In the large assembly which met at his funeral, words spoken by several who knew him well, and whose standard of character was high, were such as might fulfil the aspirations of the most saintly of men, and which very few, indeed, could deserve.

Stated Meeting, Oct. 20, 1871.

Present, nine members.

Curator, Dr. Carson, in the chair.

A letter, acknowledging receipt of No. 86 proceedings, was received from the University of the City of New York.

Donations for the Library were received from the Revue Politique; the Astronomer Royal of England; the Editors of Nature; the R. Institute of Cornwall; Thomas P. James, Esq; the Editor of the Old and New; the American Chemist; American Journal of Medical Sciences, and Medical News and Library.

A letter was read from Professor Cope to the Secretary, dated Fort Wallace, Kansas, 10th month 9, 1871, giving a preliminary report of his expedition into the Valley of the

Smoky Hill river, Kansas, and descriptions of new fossil sauroids and Chelonians discovered and collected there.

Pending nominations No. 679 and new nominations, Nos. 680 and 681 were read, and the meeting was adjourned.

Fort Wallace, Kansas,
October 9th, 1871.

My Dear Prof. Lesley :—

I write to give a brief account of the expedition of seventeen days, which I have just made in the valley of the Smoky Hill river in Kansas. Through the courtesy of Gen. Jno. Pope, commanding the Department of the Missouri, I was furnished with an order on the post commandant at Fort Wallace for a suitable escort. This was furnished by Capt. E. Butler (5th infantry), who spared no pains to make the expedition a success.

We first camped at a spring eighteen miles south of Fort Wallace, and five miles south of Butte Creek. It had a fine flow of water, and being without name I called it Fossil Spring. On a bluff, on Butte Creek, Lieut. Whitten discovered the fragments of a monster saurian projecting from the shale, and on following the bones into the hill, exhumed a large part of the skeleton of *Liodon dyspelor* Cope (Proceeds. A. P. S. for 1870). This was welcome, as the species had been previously known from vertebræ only. The pelvic arch was found perfectly preserved, and the scapular arch and limbs partially so. The iliac bone is slender and straight, slightly expanded at the acetabulum. The ischium has a somewhat similar form, but is curved. The axis of the proximal portion is directed upwards; the shaft then turns into a horizontal direction, and lies beneath and at one side of the vertebral column without uniting with its fellow. The pubes are elongate, but wider than the other elements and flattened. They are in contact in front medially, and have an angulate axis. A short process projects from near the proximal end, on the exterior margin. The femur is a flat bone, slightly constricted medially, and with a decurved and projecting portion of the proximal articular, surface on the inner side representing a head. The extremities of the dentary bones are each drawn to an acute point differing thus *toto coelo* from those of the *L. proriger.*

On the same bluff another *Liodon* and a *Clidastes* were found, with five species of fishes.

On examining neighboring bluffs and denuded areas, bones supposed to be those of *Pterodactyle*, two species of *Clidastes*, a *Dinosaur*, a *Crocodile*, and numerous fishes were brought to light.

In a similar location on Fox Creek canon, one of the escort, Martin V. Hartwell, to whom I am indebted for many fine discoveries, observed the almost entire skeleton of a large fish, furnished with an uncommonly

powerful offensive dentition. The jaws were stout, the dentary bone very deep. The teeth in a single row in all the bones, but of irregular sizes. There are two or three very large canines in each maxillary, and one in the premaxillary, three or four in the dentary separated by an interval. The lack of coronoid bone and many other characters show that it should be referred to the order *Isospondali*, and is probably allied to the herring and the *Saurodontidae*. The vertebræ are grooved, and there is a basi-occipital tube but little developed. The teeth are simple cylindric conic, with smooth enamel, and project two inches above the alveolar border, and each descends an inch into its alveolus. The species and genus are new to our palaeontology, and may be named *Portheus molossus*. It turned out on subsequent exploration to have been quite abundant in the Cretaceous seas. It was probably the dread of its cotemporaries among the fishes as well as the smaller saurians.

On another occasion, we detected unusually attenuated bones projecting from the side of a low bluff of yellow chalk, and some pains were taken to uncover them. They were found to belong to a singular reptile, of affinities probably to the Testudinata, this point remaining uncertain. Instead of being expanded into a carapace, the ribs are slender and flat. The tubercular portion is expanded into a transverse shield to beyond the capitular articulation, which thus projects as it were in the midst of a flat plate. These plates have radiating lines of growth to the circumference, which is dentate. Above each rib was a large flat ossification of much tenuity, and digitate on the margins, which appears to represent the dermo-ossification of the Tortoises. Two of these bones were recovered, each two feet across. The femur resembles in some measure that ascribed by Leidy to *Platecarpus tympaniticus*, while the phalanges are of great size. Those of one series measured eight inches and a half in length, and are very stout, indicating a length of limb of seven feet at least. The whole expanse would thus be twenty feet if estimated on a Chelonian basis. The proper reference of this species cannot now be made, but both it and the genuss are clearly new to science, and its affinities not very near to those known. Not the least of its peculiarities is the great tenuity of all the bones. It may be called *Protostega gigas*.

The greater part of a large *Liodon proriger* Cope was found scattered over a denuded surface at one point, his huge truncate, bowsprit-like snout, betraying his individuality at once. Portions of other examples of this reptile were afterwards found. Remains of several species of *Clidastes* occurred at various points in the neighborhood of Fossil Spring. One was found in the side of a bluff fifty feet above the bottom of the cañon; Martin Hartwell exhumed another near the *C. cineriarum* Cope almost complete.

We subsequently left this locality and encamped at Russell Springs on the Smoky Hill, twenty-six miles distant. On the way a large *Clidastes* of some forty or more feet in length was found lying on a knoll of shale, with the head displaying the palatal surface upwards. On the Smoky

our explorations were attended with success. When we shifted camp, it was to go to Eagle Tail in Colorado, whence we returned again to Fossil Spring. The richness of this locality was again apparent, and we added to our collection a number of species. Among these may be mentioned *Liodon ictericus* Cope and two new *Clidastes*. The writer originally pointed out the existence of representatives of the orders *Pythonomorpha* and *Sauropterygra*, in this cretaceous basin. Prof. Marsh's explorations determined the existence of *Ornithosauria* and *Crocodilia*. The present investigation adds *Dinosauria* and perhaps *Testudinata*, or the group that the new form *Protostega* Cope represents.

The preceding account expresses some of the points of interest observed. These, with others, now unnoticed, will be included in a final report.

The giants of this sea were the *Liodon proriger*, Cope, *L. dyspelor*, Cope, *Polycotylus latipinnis*, Cope, and *Elasmosaurus platyurus*, Cope. Of these the first was apparently the most abundant. The second was the most elongate, exceeding in length perhaps any other known reptile. The last named had the most massive body, and exhibited an extraordinary appearance in consequence of the great length of its neck.

For kind assistance, I am much indebted to Capt. Edwin Butler, post commandant at Fort Wallace, to Dr. W. H. King, post surgeon, and to Capt. Wyllys Lyman. To Lieut. Jas. H. Whitten and Sergeant W. Gardner, who accompanied the expedition, much of its success is also due.

I am, etc., EDW. D. COPE.

Stated Meeting, Nov. 3d, 1871.

Present, eleven members.

Vice-President, CRESSON, in the chair.

Letters of envoi were received from the societies at Riga Chemnitz, Wiesbaden, Lyons and Copenhagen, the University of Norway, and the Royal Geographical Society at London.

Letters of acknowledgment were received from the Nassau N. History Union at Wiesbaden, (Proceedings 78–83,) and the Imperial Society of Agriculture and Natural History at Lyons, July 20, (73–81,) requesting the completion of their series, which, on motion, was so ordered.

Donations for the Library were received from the Societies at Riga, Chemnitz, Görlitz, Wiesbaden, Lausanne, Lyons, Liverpool, Glasgow and Salem, Mass., the Berlin Academy, Geological Society, and Archæological Institute, the Austrian Geological Institute, Anthropological Society, Herr von Hauer,

Mr. Neumeyr and Dr. Emanuel Bunzel, the Danish Antiquarian Society, the Norwegian University, the Revue Politique, M.M. Delesse and Lapparent, the British Association, Meteorological Office, Meteorological, Geographical, Chemical, Geological, Zoological and Antiquarian Societies of London, the Editors of Nature, the American Journal of Science and Art, the Protestant Episcopal Diocesan of Pennsylvania, and the Chief of Engineers of the U. S. Army.

The death of Sir R. I. Murchison, in the eightieth year of his age, at London, on the 23d instant, was announced by the Secretary.

The loss by shipwreck, in a recent storm, on Lake Superior, of James T. Hodge, a member of the society, was announced by Secretary, with appropriate remarks.

Prof Cope made some general observations on the extinct Batrachian Fauna of the Carboniferous of Linton, Ohio., based on studies of material obtained by Prof. J. S. Newberry, Director of the Geological Survey of Ohio.

Twenty-seven species had been discovered up to the present time, and not one of them was a reptile; twenty-three of these were referred to the following genera: *Pelion*, Wyman, 1; *Sauropleura*, Cope, 3; *Tuditanus*, Cope, 4; *Brachydectes*, Cope, 1; *Oëstocephalus*, Cope, 6; *Cocytinus*, Cope, 1; *Molgophis*, Cope, 1; *Phlegethontia*, Cope, 2; *Colosteus*, Cope, 3; *Eurythorax*, Cope, 1.

Tuditanus, *Cocytinus* and *Phlegethontia* were described as new genera. The first represented *Dendrerpeton*, but possessed the usual three thoracic shields, a character not yet found in the former genus.

Phlegethontia embraced slender snake-like forms allied to *Molgophis*, but without ribs. *Cocytinus* was a branchiferous genus having four branchihyal bones, two basals branchihyals and two ceratohyals on each side, and with conic teeth in the anterior portion of the mandible only, on an expansion or dental plate. Limbs none in front.

Oëstocephalus was defined as having the three pectoral shields, posterior limbs only present and weak; head lanceolate; ventral armature of packed osseous rods *en chevron;* neural and haemal spines of caudal vertebrae expanded and fan-like. The six species were enumerated, viz: *O. remex*, Cope, *O. pectinatus*, C., *O. marshii*, C., *O. curvidens*, C., *O. vinchellianus*, C., *O, serrula*, C., the last three being new to science. Other new species were described, as *Sauropleura longipes*, C., and *S. brevipes*, C., *Tuditanus brevirostris*, C., *T. mordax*, C., and *T. radiatus*, C., *Cocytinus gyrinoides*, C., *Phlegethontia linearis*, C., was indicated as a species with lanceolated head, no ribs, a very elongate tail, and without limbs or ventral or thoracic armature. *Phlegethontia serpens*, C., was a larger species. A new *Colosteus*, *C. pauciradiatus* was added, and an allied form described as *Eurythorax sublaevis*. The pectoral median shield is subround and nearly smooth, and belonged to an animal of four feet in length.

Sauropleura, *Cocytinus*, *Molgophis*, *Phlegethontia* were enumerated as genera in which pectoral shields had not been observed, and *Pelion* and *Tuditanus* were characterized as the broad-headed types.

Cyclical Rainfalls at *Lisbon*.

By Pliny Earle Chase.

Read before the American Philosophical Society, Aug. 18, 1871.

The more strongly marked and decisive character of the curves of lunar monthly rainfall, in Philadelphia than in Great Britain, (*ante* v. x., pp. 523–34,) rendered me desirous of obtaining observations from some European station in lower latitude. The intimation of that desire to the Director of the "Observatorio do Infante Dom Luiz," at Lisbon, was promptly followed by the transmission of a copy of observations extending over a period of sixteen years, which is herewith presented. I also submit some of the tabulated results of such discussion of the observations as I have already undertaken, which appear to me to corroborate, in a most satisfactory manner, the views I have hitherto advanced respecting the meteorological influence of the moon. Some of the tables also afford interesting indications of a somewhat similar planetary influence, sufficient, as it seems to me, to encourage further investigation.

One of the objections most often urged against the acknowledgment of

TABLE I.

Different and non-correspondent Rainfalls at Lisbon, in Lunar and Solar periods, from December 1, 1854, *to December* 1, 1870. *R.=Total fall; N.=Normal percentage of rain.*

☽ DAY OR ☉ YR. ÷ 30.	LUNAR MONTHLY.							SOLAR YEARLY.						
	Dec. Mar.		Apl. July.		Aug. Nov.		Yr.	1855+3N*		1856+3N*		1857+3N*		Av.
	R.	N.	R.	N.	R.	N.	N.	R.	N.	R.	N.	R.	N.	N.
1	298.0	123	45.9	82	154.5	95	106	184.7	102	275.7	192	238.9	160	1·6
2	223.9	115	79.7	89	143.1	104	106	120.7	121	329.7	186	112.6	143	148
3	174.8	97	53.5	94	156.5	103	99	216.8	158	139.9	161	121.8	131	152
4	136.9	85	63.6	97	124.4	93	90	451.3	192	176.4	138	161.4	130	158
5	153.5	83	75.9	98	104.9	81	85	342.9	194	193.6	127	109.0	135	156
6	189.8	81	68.3	96	66.3	78	83	257.4	164	94.0	123	192.9	133	142
7	141.8	78	42.9	94	113.5	89	84	224.0	121	242.6	119	131.1	116	119
8	106.7	78	88.8	93	181.1	102	89	69.5	87	102.2	112	92.2	94	97
9	187.2	85	37.4	96	118.0	104	93	106.0	75	118.5	109	16.7	91	90
10	182.9	95	83.1	102	168.9	98	98	130.6	70	164.3	110	147.6	114	95
11	185.3	108	67.7	109	74.0	98	105	112.5	69	200.7	99	191.8	132	95
12	252.0	121	83.3	116	111.7	114	118	118.9	59	33.8	75	168.8	118	80
13	269.8	128	71.6	121	267.0	132	128	78.8	42	84.0	49	33.7	81	45
14	271.7	124	113.0	118	187.0	133	126	11.2	23	36.8	31	64.9	49	32
15	173.1	118	46.2	107	118.7	122	118	6.8	11	5.3	17	12.3	25	17
16	214.7	119	73.2	101	146.9	122	117	15.8	7	16.4	9	5.2	12	9
17	272.6	128	53.5	107	195.1	134	126	7.9	6	1.8	7	5.9	7	7
18	260.8	135	89.5	123	204.1	141	135	6.5	7	0.0	8	0.0	12	9
19	266.0	136	102.9	138	207.5	132	135	12.9	12	33.2	11	11.1	26	16
20	289.8	124	97.3	145	135.5	114	124	27.6	23	2.1	22	86.1	39	27
21	199.1	101	105.7	135	98.9	98	106	52.1	45	20.8	50	35.3	46	47
22	99.3	75	91.7	108	163.9	87	85	93.5	83	118.6	97	35.7	54	80
23	105.1	60	30.1	74	69.5	77	68	231.2	120	261.2	135	63.5	72	116
24	97.2	57	12.0	58	84.0	72	62	342.7	166	223.1	150	148.0	92	141
25	123.2	64	42.4	64	120.7	72	67	304.1	192	157.6	142	74.8	109	153
26	112.3	76	67.5	82	65.4	77	77	208.5	212	152.3	134	140.4	135	166
27	244.7	87	61.6	94	134.4	82	86	625.4	216	226.5	131	143.2	174	177
28	118.7	95	79.6	94	124.2	83	91	275.6	182	101.5	134	341.4	200	171
29	219.1	105	52.0	86	102.7	81	93	85.9	131	214.0	150	177.8	195	154
30	214.7	118	44.5	79	71.4	84	100	177.3	104	218.6	174	143.5	177	146

* 1855, '58, '61, '64, '67, '70; 1856, '59, '62, '65, '68; 1857, '60, '63, '66, '69

any appreciable lunar or planetary influence upon rainfall or other atmospheric phenomena, is based on the different, and sometimes contradictory, results obtained by different investigators, from observations in different places and at different times; another arises from the difficulty of conceiving any tidal or other force adequate for the production of any considerable disturbance. Nevertheless, such of the objectors as are familiar with Howard's discussion of the moon's influence upon the barometer; Sabine's, of lunar disturbances of terrestrial magnetism; or Schwabe's and Wolf's, of the dependence of sun-spots upon planetary configurations, seem to admit—at least I am not aware that any of them deny—the probability of the conclusions which those eminent observers have severally expressed.

If it is conceivable that Saturn, Jupiter and Venus can in any way affect the cloudiness, or amount of spotted surface of the the sun, notwithstanding the immense preponderance of his attractive, magnetic and other supposable forces, it is surely much more easy to imagine that they may similarly affect the meteorologic phenomena of the earth, which opposes an antagonizing mass only $\frac{1}{326800}$ (according to Newcomb's estimate) as great as that of the sun. If the lunar tides of our atmosphere are of sufficient magnitude to affect the barometer, the consequent waves must effect a blending of aerial currents of different temperatures and

TABLE II.

Correspondent Rainfalls at Lisbon, in Lunar and Solar periods.

☽ DAY OF ☉ YR. ÷ 30.	LUNAR MONTHLY.							SOLAR YEARLY.						
	1855–60.		1861–65.		1866–70.		Av.	1855–60.		1861–65.		1866–70.		Av.
	R.	N.	R.	N.	R.	N.	N.	R.	N.	R.	N.	R.	N.	N.
1	115.0	87	170.1	97	178.7	141	104	222.4	131	298.2	150	178.7	171	146
2	146.8	85	154.2	95	151.9	144	103	235.6	148	208.5	144	118.9	155	148
3	116.2	84	134.3	90	150.4	133	98	231.0	162	78.6	145	168.9	146	152
4	108.4	85	147.0	83	96.6	117	91	369.9	162	290.0	162	129.2	148	158
5	158.7	87	106.3	76	119.0	101	86	218.5	142	283.5	175	143.5	154	156
6	124.7	87	108.0	73	84.7	86	81	103.1	119	236.7	163	204.5	150	142
7	102.9	90	102.8	77	69.6	73	81	223.8	108	226.9	128	147.0	126	119
8	158.2	99	172.8	83	53.4	66	85	162.3	105	51.6	89	50.0	96	97
9	173.5	112	93.3	87	76.0	66	91	126.6	101	73.9	71	40.7	95	90
10	162.4	126	180.3	93	73.3	69	94	209.6	97	98.6	76	134.3	118	95
11	231.9	139	120.1	103	80.9	79	110	124.2	88	140.9	85	239.9	124	95
12	235.5	145	193.6	117	98.1	99	123	111.8	74	163.5	79	46.2	91	80
13	205.2	140	264.1	124	164.5	118	128	112.5	59	52.6	56	31.4	47	55
14	216.2	128	153.6	118	102.9	125	123	75.8	40	31.4	31	5.7	21	32
15	118.1	119	152.3	109	154.8	121	116	3.9	22	11.8	15	8.7	12	17
16	194.4	121	193.6	105	91.3	116	114	15.8	10	7.7	7	13.9	10	9
17	199.1	130	136.6	108	117.6	118	118	.8	5	6.2	5	8.6	12	7
18	202.7	133	165.9	119	114.7	128	127	.3	7	.1	7	6.1	15	9
19	239.2	123	246.6	135	176.8	137	131	21.2	14	1.5	15	34.5	20	16
20	120.4	102	234.4	141	144.6	127	123	38.2	24	68.6	26	9.0	31	27
21	104.9	81	251.9	128	113.0	99	104	49.4	40	22.0	47	36.8	51	47
22	117.3	65	135.3	105	40.3	69	82	76.9	79	60.8	86	110.1	72	80
23	60.8	55	92.5	91	29.4	55	69	218.4	124	261.7	136	75.8	79	116
24	58.6	56	158.0	90	70.8	56	70	350.6	159	254.0	171	109.2	73	141
25	87.8	70	182.3	93	78.8	59	77	255.7	179	312.1	176	8.7	79	153
26	175.8	86	112.8	91	28.3	65	84	298.5	194	156.8	165	45.9	124	166
27	149.2	93	143.4	90	72.4	81	89	458.0	191	238.4	156	298.7	185	177
28	96.8	93	148.9	91	133.2	103	95	223.6	163	233.9	149	261.0	211	171
29	180.4	92	145.5	93	129.8	118	99	134.8	130	177.9	143	165.0	200	154
30	121.2	90	141.2	95	97.9	130	102	179.3	121	141.4	145	218.7	185	146

different degrees of humidity; and in consequence of the stratification of the upper and lower winds, this blending offers a unique opportunity for the practical study of the opposite tidal tendencies in deep and shallow fluid seas or envelopes. If the lunar are as unmistakable as the solar modifications of magnetic phenomena, the analogies which have been pointed out, by Messrs. Baxendell and Bloxam between magnetic and pluvial and by myself between pluvial and auroral curves, are indicative of other possible lunar influences which are equally unmistakable. If the difficulty of conceiving an adequate cause for a supposed phenomenon were to deter us from inquiring whether an apparent dependence were real or illusory, all progress in science would become impossible. Finally, if it can be shown that solar rain-curves exhibit different, and often contradictory inflections, similar to those which are objected to in the lunar curves, and if a consistency of disagreement can be shown between the lunar results at two given stations, accompanied by a consistency of agreement between the results in different cycles at the same station, the argument from apparent contradiction will be deprived of all its force.

I have no hope of thoroughly convincing any one who is skeptical of lunar influence on the weather by deductions from observations at one or two, or a half dozen stations, but I believe that any one who will examine, carefully and impartially, the tables I have already published, based on observations in India, Great Britain, Portugal, Canada and different portions of the United States, will at least be willing to admit

TABLE III.

Lisbon Rainfall in Synodic years of Jupiter.

Syn. Yr. ÷ 30.	1853–60.	1861–65.	1866–71.	Dec. Mar.	Ap'l. July.	Aug. Nov.	Year.
1	141	177	45	139	70	110	117
2	127	148	41	121	74	93	[illegible]
3	111	101	49	87	78	90	[illegible]
4	98	65	70	62	79	94	[illegible]
5	89	48	99	61	78	97	[illegible]
6	81	43	128	70	80	96	[illegible]
7	79	43	146	78	89	102	[illegible]
8	88	45	151	84	96	112	[illegible]
9	110	45	150	95	97	117	[illegible]
10	139	45	143	106	103	112	[illegible]
11	156	44	141	105	121	121	[illegible]
12	146	39	154	90	137	143	[illegible]
13	119	36	165	77	133	151	[illegible]
14	99	37	146	74	115	124	[illegible]
15	99	37	112	83	94	81	[illegible]
16	108	36	100	100	89	51	[illegible]
17	109	45	114	113	104	46	[illegible]
18	96	68	132	117	125	60	[illegible]
19	80	98	138	121	131	79	[illegible]
20	67	123	127	126	115	84	[illegible]
21	53	131	101	117	91	79	[illegible]
22	45	129	73	95	78	76	[illegible]
23	53	134	58	79	87	91	[illegible]
24	72	153	58	79	111	112	[illegible]
25	84	168	60	95	127	114	[illegible]
26	83	196	60	117	123	99	[illegible]
27	86	200	61	128	110	93	[illegible]
28	106	191	64	125	100	110	[illegible]
29	132	183	61	124	90	130	[illegible]
30	145	183	53	133	76	130	[illegible]

that the question is an open one. And if he will compare my previous tabulations with those which accompany the present paper, he may, perhaps, find any lingering skepticism shaken, however prejudiced or inveterate it may be.

For convenience of comparison, I represent, in each instance, the mean rainfall for the entire period under consideration by 100, and any deviation from the mean, whether of excess or deficiency, is denoted by the addition or subtraction of a corresponding percentage. The smoothing by successive means is uniform in all the tables. I invite special attention to the columns of lunar rainfall at Lisbon, in each of the first two tables, representing two different sets of three independent periods, averaging 64 months, a cycle which I have hitherto supposed too short to yield any satisfactory results. If there is no causal nexus, it is difficult to imagine any possible reason for the striking similarity between the ordinates for the different cycles, a similarity which I think quite as striking as that between the solar curves at the same station for independent periods of similar duration. If the lunar disturbances are considered as merely tidal, while the solar are partly tidal, but principally thermal, their relative magnitudes suggest interesting comparisons between centrifugal and centripetal forces, analogous to those which I have hitherto had the honor of presenting to the Society.

The resemblance between the independent curves in Table III. is not very marked ; but the yearly mean is curiously like the yearly averages of the lunar monthly ordinates in Tables I. and II., if we construct the curves so as to compare the ordinate of Jupiter's opposition, No. 16, with the ordinate of lunar conjunction, No. 1, and *vice versâ*.

TABLE IV.

Comparative Daily and Yearly Rainfalls.

⊙ Hr. + Obs. 24.	PHILADELPHIA.							GREENWICH.		
	June.	Dec.	April.	Oct.	Averge Daily.	Ave'ge Annu'l.	Jan.	July.	April.	Oct.
1	123	92	120	114	91	92	53	92	120	99
2	111	78	130	112	91	89	54	103	143	126
3	92	72	127	103	93	89	63	107	169	148
4	77	71	118	97	98	90	66	112	179	146
5	69	71	103	106	105	91	64	118	155	122
6	71	73	86	105	110	94	65	129	110	98
7	79	81	77	105	113	99	72	139	74	82
8	84	95	78	110	113	105	74	140	60	75
9	80	102	78	125	112	110	72	136	59	79
10	68	96	70	140	109	113	78	133	63	85
11	56	87	64	143	105	112	99	128	65	82
12	55	85	67	135	102	110	127	109	66	72
13	66	90	74	117	103	109	141	89	72	65
14	92	100	82	93	106	111	131	94	86	66
15	131	116	94	71	109	112	111	126	101	76
16	172	136	111	58	108	108	97	148	115	97
17	186	144	124	55	104	101	98	129	125	121
18	162	133	124	56	98	95	116	88	124	133
19	123	113	122	65	92	91	145	56	111	129
20	98	102	125	79	87	95	170	40	90	121
21	90	106	123	97	85	96	173	30	73	112
22	92	119	106	106	87	96	150	32	66	98
23	102	124	93	107	90	96	110	49	76	85
24	118	112	101	109	91	95	72	73	98	84

The tendency to opposition between rainfall curves on opposite sides of the Atlantic, of which I have already submitted some illustrations to the Society (*ante*, p. 38, &c.), is interestingly shown near the solstitial and equinoctial periods, by Table IV.* Columns 6 and 7 of the same table indicate a similarity between the curves of daily and annual rainfall at Philadelphia, which lends additional interest to my comparison of pluvial and auroral curves (*ante*, pp. 121–22).

Explanation of Figures.

The horizontal lines represent the average rainfall; each vertical space represents a deviation of .2 of the mean value; each horizontal space represents two days in the abscissas of the lunar curves, or $\frac{1}{15}$ of a year in the abscissas of the solar curves. The lunar curves begin and end with the day of new moon; the solar curves with January 1.

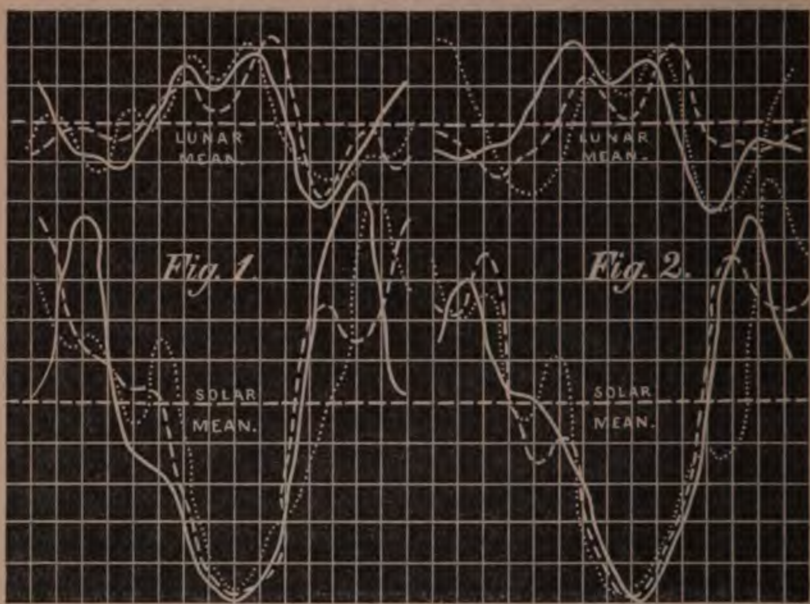


Fig. 1.—*Lunar Curves.*

December to March, inclusive; continuous line.
April to July, inclusive; broken line.
August to November, inclusive; dotted line.

Solar Curves.

1855, '58, '61, '64, '67, '70; continuous line.
1856, '59, '62, '65, '68; broken line.
1857, '60, '63, '66, '69; dotted line.

Fig. 2.

1855–'60; continuous line.
1861–'65; broken line.
1866–'70; dotted line.

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LISBON RAINFALL.

Dec. 1, 1854, to Dec. 1, 1855.

Day.	Dec.	Jan.	Feb.	Mar.	Ap.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Total
1			4.3			4.3	0.8				16.5	0.3	26.2
2			26.7		0.5	1.1					1.5		29.8
3	1.9		2.2	0.5		14.3				2.2	0.4		21.5
4	4.9		8.1	19.5		3 2				13.2	8.9		57,8
5			8.6	2.7		2.3				1.3			14.9
6	0.5		5.7			0.3					7.6		14.1
7			0.5	4.0			0.3			0.6	16.2		21.6
8			3.5	3.3						8.6	6.5		21.9
9			7.6	1.3						2.4	52.8	4.4	68.5
10			8.9					13.2		0.5	2.2	1.5	26 3
11			2.4								0.3	0.1	2 8
12			27.0										27.0
13		0.5	23 8		0.2						13 0		37.5
14		0.3	3.5		2.2						13 5		19.5
15			8.6		0.3	0.3					2.7	0.7	12.6
16		0.6	24.6		16 2	1.1							42.5
17		0.8	2.5		8.1						17.0		28.4
18		3.0	19.2		0.3						6 3	2.3	31 1
19		2.4	7.3		4.3					0.3	0.3	10.7	25.3
20			6.0	3.5									9.5
21				6.2	11.1							16.4	33 7
22		0.5	14.3	4.6	3.8					20.0	11.9	10.9	66.0
23			0.8	6.5	0.5					0.8	9.2	13.0	30.8
24				15.9							0.6	1.0	17.5
25			0.5	2.7	8.1	5.6							16.9
26		17.3		18.9		31.3				8.4			75.9
27		19.7		27.2		3.0			0.8	0.5	5.0		56.2
28		1.1	0.5			7.3				4.0	4.0		16.9
29		9.7		9.2		14.6				30.5		6.6	70.6
30				0.5		0.8		0.3		0.8	0.8	2.0	5.2
31						1.1					1.3		2.4
Sum	7.3	55 9	217.1	126.5	55.6	90.6	1.1	13.5	0.8	94.1	198.5	69.9	930·9

Dec. 1, 1855, to Dec. 1, 1856.

Day.	Dec.	Jan.	Feb.	Mar.	Ap.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Total
1		8.5	16.8		6 2	6.1							37 6
2		7.3	3.3		3.2						0.8		14 6
3		30.6	6.9		0.8						0.6		38.9
4		3.6			9.9					1·3	0.4		15.2
5		28.3			3.8					0·1	50.9		83.1
6		9.4			0.3					0·1	4.1		13.9
7	8.6	12.9		7.7									24 2
8		12.9		3.8	11.8						1.1		29.6
9		12.9		0.2	2 4							1.5	17.0
10	1.0	11.4		1.1	0.9								14.4
11	1.6	6.2		2.6									10.4
12				6.0	6.7							1.9	14.6
13		0.8	10.8	1.5	7.6						3.5		24.2
14		0.3	5.1	11.7	0.7								17.8
15		6.2	6.8	5.4	6.2								24.6
16	0.7	11.3	1.7	43 4									57.1
17	6.7	0.8	7.0	26.5	0.3				1.0				42.3
18	4.9	40.9	3.4	12.1					6.2			0.7	68.2
19	0.8	18.7	16.8		0.7								37 0
20	27.5	8.4	1.8		0.3				1.3				39.3
21	3.4	11.7	1.1			1.1							17.3
22		0.5											0.5
23	0.3	1.6	18.3	0.3		2.3							22.8
24	0.8	6.3		4.1	16.5	1.5				4.3			33.5
25	3.7	24.8			6.0	0.3							34.8
26	5.8	7.9		18.9	35.9								68.5
27	46.8	3.9		5.5	6.8					9.2			72.2
28	1.9	3.5		0.6	1.3	1.2				0.1			8.6
29				0.5	3.6	4.4				4.3		0.1	12.9
30													
31	12.5										5.3		17·8
Sum	122.0	291.6	99.8	151.9	131.9	16.9	0.0	0.0	8.5	19.4	66·7	4.2	912.9

LISBON RAINFALL.

Dec. 1, 1856, to Dec. 1, 1857

Day.	Dec.	Jan.	Feb.	Mar.	Ap.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Total
1				2.4	7.9		3.6				3.2	17.7	34.8
2	5.0		8.3	0.6		0.3		0.2			0.9	6.5	21.8
3	8.5	1.3	5.0		0.7	1.0						27.6	44.1
4	0.1	1.3	0.2		1.3							5.2	8.1
5	10.5	0.4			0.3							10.6	21.8
6	3.0	7.6				0.5							11.1
7			0.1	1.1		1.1					7.6		9.9
8	0 7		6.6	1.1		0.7				0.2			9.3
9	20.7		39.5		3.5	1.3				1.0			66.0
10	6.7		30.0		1.1	14.9				1.0		1.8	55 5
11	0.9	1.4	12.2	1.3									15.8
12	2.0	6.5	0.2										8 7
13	11.3	4.8	0.5	3.2		0.7							20.5
14	0.5		3 5	0.1	0.1	0.7							4.9
15			1.2		0.2		0.6					4.3	6.3
16			6.2				10.0					28.9	45.1
17			1.9	4.3			15.6					11.5	33.3
18				7.4			4.8				12.0		24.2
19			5.1								17.5		22.6
20		0.3	1.7	17.3						5.9			25.2
21	5.0	9.2		0.2		1.7				2.0			18.1
22	1.5					1.9			0.7	1.0			5.1
23		0.5	0.2			10.4			25.9			28.0	65.0
24		8.1	0.7	11.1		26.0				0.3	4.3	0.6	51.1
25	0.5	6.5		0.2		1.5				3.2	19.9	12.0	43.8
26	8.9	1.2			0.2	2.4					11.0	1.0	24.7
27	0.9	0.5				2.1					0.9		4.4
28	2.6			1.1					0.3			21.5	25.5
29									6.2		1.4	35.4	43.0
30				12.2	0.7					3.1		11.4	27.4
31		5.8		5.4							4.0		15.2
Sum	89.3	55.4	123.1	69.0	16.0	67.2	34.6	0.2	33.1	17.7	82.7	224.0	812.3

Dec. 1, 1857, to Dec. 1, 1858.

Day.	Dec.	Jan.	Feb.	Mar.	Ap.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Total
1				30.5	0.3	0.2		0,1					31.1
2				15.0	0.2	0.7							15.9
3	21.1			6.8		0.2							28.1
4	0.4	8.8	2.5	7.5		5.0						17.3	41.5
5			7.5		0.6							0.8	8.9
6			0.6										0.6
7		4.8	5.7		4.8								15.3
8			0.3		3 3							1.2	4 8
9			8.1		1.4	5.0						40.5	55 0
10			8.5			6.0					12.6	37.2	64.3
11			10.0			2 9					0.1	0.4	13.4
12			13.3	1.8	2.5	0.2						20.4	43.2
13			0.8									7.8	8.6
14												4.7	4.7
15						2.0						55.9	57.9
16										0.6		0.6	1.2
17			12.0								21.5	6.7	40.2
18			17.6				0.2		2.6		7.5	60.9	88.8
19	13.8										30 5	0.8	45.1
20			4.0							29.3	2.3	10.2	45.8
21			20.8	0.2						8.2		3.7	32.9
22			14.7								1.9	22.0	38.6
23			1.9	8.4							17.1	22.8	50.2
24			67.						1.1		7.9	26.9	42.6
25			0.6						0.2			27.9	28.7
26		9.6	6.2									14.6	30.4
27		8.7	4.0							6.6		6.3	25.6
28			6 2							7.0		2.0	15.2
29							2.9					9.7	12.6
30				2.0								13.2	15.2
31				5.7									5.7
Sum	35.3	31.9	157.0	77.9	13.1	22.2	3.1	0.1	3.9	51.7	101.4	414.5	912.1

LISBON RAINFALL.

Dec. 1, 1858, to Dec. 1, 1859.

Day.	Dec.	Jan.	Feb.	Mar.	Ap.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Total
1			0.5			2.2	9.0						11.7
2	0.3		0.2			0.3	8.3						9.1
3	0.5					3.8	1.3					9.8	15.4
4						23.3	1.2				1.5	20.3	46.3
5			2.9			1.0	4.4				0.6		8.9
6			2.0			0.6	12.2				9.6		24.4
7			6.0				13.8				0.8		20.6
8			0.5				3.4				19.3		23.2
9							3.9				4.2		8.1
10			13.6		0.3						0.8		14.7
11			0.5		0.2						20.0		20.7
12			0.2			19.1	7.9				40.7		67.9
13	9.8					10.7	0.8				13.0	1.5	35.8
14				0.5			1.4				6.2		8.1
15							2.9			0.4	12.2		15.5
16	25.4												25.4
17	2.0					0.1				0.4	9.3		11.8
18	13.7				28.1				0.3		0.5		42.6
19	1.9				19.3			0.8					22.0
20	1.2				5.3	6.6						20.7	33.8
21		1.8			4.2						5.1	9.5	20.6
22		17.3			3.3	2.7					11.0	4.2	38.5
23	15.0	0.3			0.1						1.6	0.5	17.5
24	3.1				1.0							8.7	12.8
25											23.0		23.0
26		0.2			0.3							0.1	0.6
27					18.0						17.0	0.8	35.8
28	0.2	0.1			0.4	1.7				1.0	31.7		35.1
29				4.1	19.9	3.4							27.4
30		5.5		1.0	4.2	12.4					0.6		23.7
31		3.3				3.7					0.3		7.3
Sum	73.1	28.5	26.4	5.6	104.6	91.6	70.5	0.8	0.3	1.8	229.0	76.1	708.3

Dec. 1, 1859, to Dec. 1, 1860.

Day.	Dec.	Jan.	Feb.	Mar.	Ap.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Total
1	0.4	2.5	0.1		14.3					2.7		2.1	22.1
2		12.6					1.3			6.3		1.7	21.9
3	14.4	7.7			12.1								34.2
4		2.4			7.7							0.6	10.7
5		6.3			1.8								8.1
6	5.1	3.2			0.4							12.5	21.2
7				4.4								3.6	8.0
8	11.2	0.5	3.9									1.5	17.1
9		0.4	2.9				4.7	2.5		6.3		2.4	19.2
10		1.9										23.5	25.4
11				2.4						1.6		9.8	13.8
12		1.6	0.3	2.0		2.1	1.5					1.0	8.5
13		37.1		1.3			3.5					14.8	56.7
14		0.3				2.7						0.2	3.2
15				0.1			5.2		10.1			7.2	22.6
16		4.7										14.8	19.5
17		4.6			2.1	0.7						4.9	12.3
18		12.6			1.0	12.2				0.8		1.5	28.1
19		0.4					7.0					1.2	8.6
20		6.1					3.8					3.1	13.0
21		0.2											0.2
22		3.7	2.4									1.0	7.1
23	0.5	0.9										1.2	2.6
24	0.3	2.0	4.5							0.5		1.2	8.5
25	22.6	0.6	12.7		30.9							5.7	72.5
26		0.2			15.5							4.9	20.6
27	3.7	2.3	0.5							12.0		6.4	24.9
28	4.6			5.1						1.2	3.8	9.4	24.1
29	3.2										7.7	5.4	16.3
30	0.1	0.6										2.8	3.5
31		2.1		3.6									5.7
Sum	66.1	117.5	27.3	18.9	85.8	17.7	27.0	2.5	10.1	31.4	11.5	144.4	560.2

LISBON RAINFALL.

Dec. 1, 1860, to Dec. 1, 1861.

Day.	Dec.	Jan.	Feb.	Mar.	Ap.	May.	June.	July	Aug.	Sept.	Oct.	Nov.
1	17.4										1.6	0.3
2	23.4					1.0					12.6	
3	12.1	6 2									9.2	
4	4.4	0.4										
5	4 3	15.4						0.5				
6	15.8	1.0	3.2								4.8	
7	28.5		15 4								1.6	
8	17.5		3.0			7.2						16.4
9	1.2		43.3									
10	2.6		19.7				2.7				25.7	14.0
11	1.2		0.2							2.9		2.8
12			4 8								0.8	5.9
13	2.6		2.1									6.1
14	0.3	6.1	31.5				0.2	2.6			5.2	
15		20.5	5.6		5.7						36.3	
16		2.0	1.1			16-3	1.2				10.8	7.2
17			18.5			7.3	4.2					15.8
18	1.3		29.9			6.4						4.8
19	0.8		3 3		1.3						3.8	1.4
20			7.1		9.4	2.6						31.6
21	6.0		2.6		4.0						1.3	6.6
22	10 4		28.7		1.6						0.1	
23	6.4		3.7			2.8	2.8					
24	30.3		0.2		4.0					2.4		0.4
25	14.6									3.7		4.4
26	0.3		2.9		0.6	6.0		0.4			14.0	1.2
27	7.1			13.8		24.7					6.8	
28	13.6			1.0	31.8	5.6					22.5	
29	1.0				1.0	0.2					4 9	
30										15.0		
31											6.5	
Sum	223.1	51.6	226.8	14.8	59.4	80.1	11.1	3.5	0.0	24 0	168.5	118.9

Dec. 1, 1861, to Dec. 1, 1862.

Day.	Dec.	Jan.	Feb.	Mar.	Ap	May.	June.	July.	Aug.	Sept	Oct.	Nov.
1		2 2		23.5		0.3						
2		19.6		13.5	0.9							
3		1.4		13.1		5.3						
4		0.9				4 6						
5						5.3		5.3				
6				4.2								
7	0.2			17.7		0.4						
8		3.2		1.5								
9	1.7	0.8		12.6						2.7		
10	6.7										1.5	
11		1.5			0.1		0.2					1.0
12		1.3			11.0							
13	24.2	0.9			2.2							
14	1.0											
15			17.1		2.3	14.8	0.5			4.8	8.5	
16		0 2	15.5	22.8								
17			16.3									
18		2.1	35.7	13.1								
19		5.1	34.9	31.5							2.2	
20	1.4	25 8	0.7	9.5								9.4
21		0.4	17.6									
22		4.9								14.2		2.5
23	3.2	32.2										17.4
24		1.6	19.6	15.5	0.6					8.3		16.1
25		0.4		5.6						0.6		0.2
26			14.7	4.9		0.8				0.2		1.4
27	15.8	11.4	17.6	10.2			0.6			5.8		27 2
28	3.4		0.2	6.3	0.1							8.8
29				5.3		0.3						6.2
30	1.0			17.4	3.3	2.4				4.2		14.7
31											19.0	
Sum	58.6	115.9	189.9	228.2	20.5	34 2	1.3	5.3	0.0	40 8	31.2	104.9

LISBON RAINFALL.

Dec. 1, 1862, to Dec. 1, 1863.

Day.	Dec.	Jan.	Feb.	Mar.	Ap.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Total
1	6.6												6.6
2	22.1	1.3		4.0								1.6	29.0
3	18.7	24.8	0.3	41.0						1.9			86.7
4		34 4		24.8									59.2
5		2.0		2.1									4.1
6		9.0		12.3									21 3
7		1.1		0.6							1 4		3,1
8		3.0		8.2							1.8		13.0
9		24.2		4 8		0.1	1.8				19.5		50.4
10		1.3		8.0	0.2						11.8		21.3
11				1.2	0.6		4.6				2 2	1.0	9 6
12			4.3	1.1							17.3		22.7
13				7.7	2.2					8.6	1.0		19.5
14				0.1							4.4		4.5
15				1.0									1.0
16				0.5									0.5
17													
18						0 5							0.5
19										1.5			1.5
20						3,4							3.4
21					0.2	17.0		1.8		0.5		1.2	20.7
22						26.0		2.2		0.3			28.5
23						6 6				1.1	0.3	7.2	15 2
24		4.2				17.1				1.4			22.7
25					2.5	2.8	0.2			2.0	2.5		10.0
26							0.6		46 8		5.0		52.4
27									2.6				2.6
28							3.5		0.6				4.1
29	2.5												2 5
30	14.3	5.1								4.6	1.3		25.3
31		2.6									0.2		2.8
Sum	64.2	113.0	4.6	117.4	5.7	73.5	10.7	4.0	50.0	21.9	68.7	11.0	544.7

Dec. 1, 1863, to Dec. 1, 1864.

Day.	Dec.	Jan.	Feb.	Mar.	Ap.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Total
1				9.2			7.0				8.2	0.9	25.3
2											1.3	2.4	3.7
3				0.4			6.6				17.2		24.2
4				18.8			0.6				7.0		26.4
5				0 4									0.4
6				17.0							2.8		19.8
7		24.0	0.4	17.3		4.0					13.0		58.7
8		0.6	9.3	1.5		0.8							12.2
9		20 3	6 1	14.4		12.0					4.9	0.4	58.1
10			3 4	1.5		3.4						5.0	13.3
11		3.8			0.1								3.9
12		21 1			6.5								27.6
13					7.2								7.2
14					4.2		2.7	0.2				3.0	10.1
15					5.9					0.2		0.2	6.3
16		3 2			0.4					15.8		0.2	19 6
17		1.9		0.5							0.9	12.6	15.9
18				19.0						0.4	16.5		35.9
19				13.5							3.5	11.0	28.0
20				15.1	5.9						9.4		30.4
21				6 7	11.3						32.1		50.1
22			4.1	0.2	4.2				16.8		7.5		32 8
23			9.9	31.0	4.3						17.3	12.3	74.8
24			16.8			12.0					27.5	4.0	60.3
25			3.3	5.9		7.0					5.8	6.0	28.0
26			8.6		7.5	10.5				0.1	28.1	1.7	56.5
27			10.3	1.1						9.2	7.8		28.4
28			0.3							14.9	11 3	0.3	26.8
29			7.1								0.2		7.3
30										0.2	30.1		30.3
31	0.8					1.5					10.3		12.6
Sum	0.8	74.9	79 6	173.5	57.5	51.2	16.9	0.2	16.8	40.8	262.7	60.0	834.9

LISBON RAINFALL.

Dec. 1, 1864, to Dec. 1, 1865.

Day.	Dec.	Jan.	Feb.	Mar.	Ap.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1		9.0	7.9	0.1			2.3					
2		0.5	3.5				0.4					
3		0.1	4.4								11.1	0.8
4			4.1			2.2					16.2	
5			0.8			11.4					0.6	5.6
6			5.0	1.1		11.2					50.6	6.0
7			10.4			26.4					35.7	
8	9.1	1.7	6.5			11.0					30.7	
9	6.2	22.1				6.9					11.0	60.6
10	3.6	0.4								10.2		19.5
11	11.9	1.6			1.0		0.2					
12	3.2	37.8							1.0		3.3	11.2
13	31.2	0.5				25.9					2.1	1.1
14	23.8	1.2		0.4	6 9	3.0			0.5			
15		0.1	1.9		3.6	3.1						
16	5.6	4.8	4.6		3.1							
17	9 6	5.3	1.2	0.1			7.8				0.2	
18	0.7	7.9		13.9			4.3				17.0	
19	2.4			2.7			1.0				0.9	12.0
20		35.5		6.6				1.0			7.2	1.0
21		13.4		2.1	4.0		3.4				20.5	8.5
22		0.1		0.8							8.2	1.9
23	0.4	18.3							1.6		0.8	15.8
24	0.4	7.3								0.4		
25		9.3								1.5		41.0
26		0.8								1.0		2.9
27		8.8			4.9				0.2		0.1	14.3
28		2.1			0.8						1.8	7.4
29		6.0			5.0					2.7	0.8	26.6
30	7.5						0.7			12.8	2.6	
31	0.9	10.2				1.0					1.0	
Sum	116.5	204.8	50.3	27.8	29.3	102.1	20.1	1.0	3.3	28.6	222.4	236.2

Dec. 1, 1865, to Dec. 1, 1866.

Day.	Dec.	Jan.	Feb.	Mar.	Ap.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1		4.6	3.4	9.3		7.3	1.5					
2	3.3		7.4	14.2	3 2		0.7					
3	12.2			13.7	1.2	2.2						
4		6.3		2.2		34.5						
5	5.7	1.9		3.5	9.8	39 5		2.4				
6	14.3				2.4	6.6					1.0	
7	3.6			3.7	0.9							
8				0.5	0.4							
9		0.6	5.3							2.6	0.4	
0		7.0	0.7								7.2	
11		14.4	19.7	1.0								
12			5.9								1.8	
13			2.0									
14			6.5	4.8								
15		0.6		16.4							0.6	
16				11.2								3.2
17				21.4							17.7	
18			1.6	17.6					1.0		2.9	
19				5.8								
20		9.4		12.9					0.3			
21		1.2		0.3		0,5					7.4	
22		0.4				4.0				4.2		
23	14.6				4.3	23.3	0.2	1.3		7.5		
24						1.7		0.6				
25					1.0	0.8	0.2			0.1		0.9
26		0.6	10.8		4.5	0.5	0.1					
27		10.0	16.4		23.3	0.7	6.3			3.7		
28			16.0		2.1	6.2				0.3		
29	5.5				32.2	0.5				2.7		8.8
30	0.8	1.2			1.0					0.3		9.0
31		0.8				12.2						
Sum	60.0	59.0	95.7	138.5	86.3	140.5	9.0	4.3	1.3	21.4	39.0	21.9

LISBON RAINFALL.

Dec. 1, 1866, to Dec. 1, 1867.

Day.	Dec.	Jan.	Feb.	Mar.	Ap.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Total
1								0.3	5.9				6.2
2	6.8											0.2	7.0
3		0.7											0.7
4		4.1											4.1
5	0.2	7.9	0.2										8.3
6	0.1	3.2	1.0	13.3		2.2							19.8
7	0.1	8.1	0.2	26.4		19.1							53.9
8		15.8		5.1									20.9
9	0.3	0.9		2.4		0.4				0.2			4.2
10		19.4		6.3		7.3							33.0
11	0.4	1.9		4.3									6.6
12	0.2	9.2		2.5	0.8	5.4				10.1		18.9	47.1
13		1.6		14.9	1.8	5.4				0.9	0.4	12.6	37.6
14		2.5		12.0		1.4					5.2	54.4	75.5
15		1.2	2.9	0.6		0.8						48.8	54.3
16			22.7	0.2								6.2	29.1
17		23.4		5.6							0.2	12.5	41.7
18		7.8		12.7		2.2					0.2		22.9
19		14.0		12.3		0.1							26.4
20		18.9			7.2	0.1	0.7						26.9
21		0.1		5.6								0.1	5.8
22		1.4											1.4
23				6.9									6.9
24		7.5		0.7				0.3					8.5
25				1.3		4 3		6.4					12.0
26	0.8			11.2									12.0
27	4.6			5.2									9.8
28				1.4	1.0								2.4
29				2.8		2.2							5.0
30					0.8							1.2	2.0
31	7.1												7.1
Sum	20.6	149.6	27.0	153.7	11 6	50.9	0.7	7.0	5.9	11.2	6.0	154.9	599.1

Dec. 1, 1867, to Dec. 1, 1868.

Day.	Dec.	Jan.	Feb.	Mar.	Ap.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Total
1	24.0				2.4						1.8		28.2
2					0.7								0.7
3					17.5			0.1					17.6
4					0.4	27 6		4.3			4.9		37.2
5					2.0	0.6							2.6
6		10.5										3.9	14.4
7													0.0
8		0.8	20.0				0 3						21.1
9	3.4	0.5		2.0			0.1						6.0
10		0.3				0.6						9.3	10.2
11		13.7		3.0				4.8	0.4	4.2			26.1
12						0.2		1.9	2.8	0.5			5.4
13		8.3								3.3	0.7		12.3
14										12.7	5.9		18.6
15									9.7	0.2	0.8	15.8	26.5
16									1.9	15.6		7.0	24.5
17	0.1									0.4		14.6	15.1
18	0.2						2.7		8.4	22.5	2.0	3.0	38.8
19		5.0	2.4		5.4					5.2			18.0
20		4.5			4.0					12.4		1.0	21.9
21					0.4		0.1			1 6		2.2	4.3
22		5.8	0.8		3.5					0.7		24.3	35.1
23		0.3			4.8		0.2					2 0	7.3
24	4.4				1.8					8.5		0·5	15 2
25	16.4											9.8	26.2
26										7.5		3.5	11.0
27			0.3				0.3			2.4		0.4	3.4
28	8									0.8		1.0	10.6
29	2.0									10.4		1.4	13.8
30	15.2									16.4		38.3	69.9
31	15.2												15.2
Sum	89 7	49.7	23.5	5.0	42.9	29 0	3.7	11.1	23.2	125.3	16.1	138 0	557 2

LISBON RAINFALL.

Dec. 1, 1868, to Dec. 1, 1869.

Day.	Dec.	Jan.	Feb.	Mar.	Ap.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	To
1			6.0			0.2					5.0		
2	23.5												
3	0.4	7.7	0.2										
4	5 2				0.2			0.2					
5	1.1					27.9							
6						16.4							
7	0 2					5.4							
8	1.5												
9				3.2		14.9					6.2		
10		12.3	0.1	3.5	1.4	0.2				1.8			
11	5.8	1.3		7.1	0.7					5 6			
12	62.7	17.0				17.9							
13	13.0	0.6		10.7		0.2	2.3						
14	2.3			7.0		0.4	0.3						
15	16 7	1.4		0.1									
16		0.2		1.1	3.3							1.0	
17	15.8		1 3								14.1		
18	0.2		8.2								7.6		
19	3.2		0.5								0.5		
20	15.5					0.3				1.0			
21	2.8		7.0	1.1									
22	5.8	1.0										1.5	
23	0.2	0.8										4.1	
24	13.3	2.0		0.3								1.3	
25	3.0			0.4	0.5	3.9							
26		17.7		0.4	0.2	3 4							
27	3.4	9.0				0.6							
28	0.3	5.0			1 4	0.7				5.0			
29	6.3	0.2		0.5	19.4	3.2	0.3			9.2			
30	0.3	16 0				0.4				1.9		0.2	
31		5.3											
Sum	202 5	97.5	23.3	35 4	27.1	96.0	2.9	0.2	0.0	24.5	33.4	8.1	

Dec. 1, 1869, to Dec. 1, 1870.

Day.	Dec.	Jan.	Feb.	Mar.	Ap.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	To
1		1.4							0.2				
2		1.0	31.2	21.7							0.2		
3	9.2	1.4	6 2	6.6									
4			5.4	11.0			2.5				5.2		
5		0.5		14.0						0.2			
6	9 9	0.6	1.1	0.5		0.8				3.0			
7	5.1		4.0	2.2	0.2					6.4			
8	7.9	1.4	0.9	2 7	0.1						21.3		
9	19.5		2.4	8.4							8.0	2.0	
10		0.5	0.6		5.5						1.2	0.7	
11	3.5		7.5					0.2			3.0	0.2	
12			1.0			3.1					0.2	5.7	
13	1.4	0.3	5.5						0.3			2.4	
14	0.8	0.4											
15	0.4	0.1	1.8								0.3	1.5	
16			9 6										
17	0.2		1.0		0.1				6.7		0.8	6.8	
18					0.4					3.1		0.3	
19	1.5		28.5						3.3	0.6		9.0	
20	19.3				30.6							15.5	
21	7.3									8.9			
22	1.7		1.2									3.0	
23	2.5		0.7								0.5	5.9	
24			6.7								0.8	32.6	
25			4.0									10.7	
26	1.4	3 9											
27	1.3	2.3	2 2		3.7							1.8	
28			3.6									1.5	
29		8.8											
30	26.4	3.0							8.7				
31	11.7	24.0											
Sum	131.0	49.6	125.1	67.1	40.6	3.9	2.5	0.2	19.2	22.2	41.5	99.6	

REMARKS *on Hyrtl's Collection.*

(Read before the American Philosophical Society.)

Prof. Cope stated that this collection embraced 800 skeletons, each with the branchial apparatus mounted separately. A large proportion of the specimens measured two feet long and upwards. The Selachians were not very numerous. Among them was to be noted a saw-fish from the South Pacific Ocean. The Dipnoi were represented by two perfect specimens of the *Protopterus annectens* from Central Africa. The Crossopterygians were present in five specimens of *Polypteri*—some from Central, others from West Africa. Of Ganoids a fine series of *Lepidosteus*, Sturgeons, *Spatularia* and *Amia*.

The series of Nile fishes was probably the best in existence. The *Mormyridæ* were especially complete and represented by large specimens. There were two of *Gymnarchus niloticus*, each three feet in length. Many of the specimens were obtained at Chartum, in Nubia, others came from Gondokoro on the White Nile between lats. 4° and 5° N.

The Australian fauna was well represented. From it might be selected the genera *Schuëttea*, *Neosilurus*, *Gadopsis* and *Parapistus*. Numerous species from Samarang, Singapore and Polynesia were included, and the *Osteoglossum formosum* from Borneo required especial mention. The ichthyology of Hindostan was well represented. The Mediterranean series was very complete. Among them was to be noted a specimen of the rare *Ruvettus speciosus*, three feet in length, one of *Trachypterus liopterus* still larger and an *Alepocephalus rostratus*. From the Canary Islands were some uncommon varieties, as *Nesiarchus nasutus* and *Centrolophus ovalis*.

The North American series was good, especially the *Catostomidæ*. There were numerous West Indian species, and a good representation of South American; chiefly from Chili, Puerto Cabello, Rio and the tributaries of the Amazon and Essiquibo. The latter were mostly from Natterer's collections, and embraced many forms of Siluroids, Characins and Chromids.

The specimens were prepared by Prof. Hyrtl himself, which was an unequalled guarantee of their completeness in all respects, to the most minute. The preparation of the supplementary ribs of the *Clupeidæ* (herring) was to be noted as an especially difficult task which had been successfully accomplished. The collection appears to have been commenced by Prof. Hyrtl not later than in 1850, and had been an object of interest to ichthyologists and anatomists for several years. It was probably the most valuable collection for study in this department in existence, and Prof. Cope thought it cause of satisfaction that it had arrived safely in the United States.*

* The liberality of Cope Brothers in transporting it free of charge from Liverpool to Philadelphia was acknowledged.

Prof. Cope remarked upon the peculiar features of some of the figures on the plates in Benzel's Reptilfauna der Gosau-formation.

Stated Meeting, November 17, 1871.

Present nineteen members.

MR. FRALEY, Vice-President, in the chair.

Mr. Phillips and General Tilghman, recently elected, were introduced to the presiding officer, and took their seats.

A photograph of Mr. Chabas was received for insertion in the Album.

Letters of acknowledgment were received from M. F. Chabas, dated Chalon sur Saône, Oct. 21, 1871 (Proc. 83, 84, 85); from the Linnean Society, London, Aug. 2 (xiv., i. 82, 83, 84, 85); and from the Smithsonian Institution (86).

A letter from the Linnean Society announced the sending of publications.

Donations for the Library were received from the Prussian Academy, the Montsouris Observatory, the Astronomical and Linnean Societies, the London Nature, the Boston Public Library and Dr. Samuel A. Greene, the Franklin Institute, the College of Pharmacy, the Medical News, the Penn Monthly, Mr. Latrobe of Baltimore, and the California Academy of Sciences.

A letter was received from Mr. Henry W. Field, dated Royal Mint, London, Oct. 22d, accepting his appointment to prepare an obituary notice of the late Sir John F. W. Herschel.

Mr. H. C. Carey read an obituary notice of the late Stephen Colwell, pursuant to notice.

The death of John Edwards Holbrook, M. D., formerly Prof. Anat. Med. Coll, South Carolina, which took place at Norfolk, Mass., Sept. 7, 1871, was announced by the Secretary.

The death of Ed. W. Brayley, F. R. S., Feb. 1, 1870, was announced by the Secretary.

A memoir for the Transactions: On the Tours of the Chess Knight, by M. Serge de Stchoulepnikoff, was received, with a letter from the author, dated Circleville, O., Nov. 3, 1871, and, on motion, referred to the following Committee; Prof. George Allen, Mr. Pliny E. Chase and General Tilghman.

A Note on the Footmark in Hieroglyphic Script, by M. F. Chabas, of the Institute of France, was read by the Secretary.

Note of F. Chabas, of the Institute of France, on the Foot-mark in the Hieroglyphic Script.

I find in the Proceedings of the American Philosophical Society (Vol. XI., p. 312) the following statement:

"Mr. Lesley referred also to the fact that the ancient Egyptian B was graphically represented by the leg, A by the arm, T by the hand, and that what is called the comb may have been meant for the foot-mark."

I am not acquainted with any hieroglyphic character bearing in its graphical form a nearer resemblance to a comb than [Mr. Chabas here gives the M as in the first King's name, Mena,] the larger drawings of which show manifestly to be a chess or draught-board with its men.

But the feet occur in the hieroglyphic script, not with a phonetic but with a symbolic worth. They are a mark of the actual presence of the delineator. When a pious Egyptian repaired to some place of worship, in a distant country, he would sometimes, as a token of his zeal, incise a figure of his two feet on some stone in the neighborhood. Similar sculptures were observable on the terrace of the temple of Khons at Karnak, and have been published by M. Prisse d'Avennes; the name, pedigree and titles of the pilgrim are generally written close to his sculptured feet, which are represented either naked or shoed; in one case they are replaced by the soles or feet-marks.

This practice was probably very old, but either from the scarcity of monuments or the neglect of observers, it can not be traced up in the first empire. One of the instances published by M. Prisse refers to the reign of Apries.

F. CHABAS.

Chalon sur Saône, Oct. 21, 1871.

Mr. Lesley explained that he referred to the comb-like syllable *Kam* which occurs frequently with the signification "black; to become black," and therefore, as the name of Egypt *Kam* "black land," the *HaM* of the Hebrew Scriptures. Its verbal meaning is "to advance or be advanced to completion," and is so used in reference to any work, building or monument. Although the figure is drawn with a square heel, yet the slant of its front end, and the setting upon it of five points like toes suggests a plausible explanation of its meaning *to advance*, provided it be allowed to represent the human foot, which otherwise does not appear in Egyptian, except in profile and in connection with the leg. Why Bunsen should call it the tail of a crocodile it would be difficult to explain. Dümichen's plates of the legends on the walls of Dendereh do not give the figure on a scale large enough to decide upon its original shape, and I have never happened to see it on the monuments.

Mr. Cope presented for publication in the Proceedings, with four octavo plates, a communication on certain extinct vertebrata in the strata of North Carolina; and illustrated a sketch of his paper by exhibiting some of these fossil remains.

The Minutes of the last meeting of the Board of Officers and Council were read.

Pending nominations Nos. 679, 680, 681, and new nomination No. 682 were read.

Mr. Fraley reported that he had duly executed the Power of Attorney in the case of the Michaux legacy and transmitted the same to M. Carlier.

The request of Dr. Somers, Prof. Chem. Southern University at Greensboro, Ala., was referred to the Committee on Publication, and the meeting was adjourned.

Obituary Notice of Stephen Colwell.

(*Read before the American Philosophical Soc., Nov.* 17, 1871.)

By Henry C. Carey.

A life protracted considerably beyond the allotted threescore years and ten has brought me, in the course of nature, to the position of survivor to a host of personal friends whose lives had made them worthy of the remembrance in which they yet are held by those who had known them best. Of one of the worthiest of those whom I have familiarly known, and for their words and their works have most esteemed, it is that, in accordance with the request with which the Society has honored me, I have prepared the brief memoir that will now be read. For its preparation and for the proper performance of duty to the departed, to his surviving friends, and to the public which has a property in his memory, I claim to have little qualification beyond that resulting from long and familiar acquaintance; from a fellowship in the public labors to which were devoted so many of his life's best days; and from an earnest desire to aid in perpetuating the recollection thereof in the minds of those whose service such labors had been performed.

An ardent pursuit of the same general course of study, in a yet unsettled department of inquiry, tends necessarily to the development of difference in modes of thought, even where, as has been the case with Mr. Colwell and myself, the end in issue is substantially the same. Between us, however, there has never been any essential difference, and while it has been among the highest gratifications of my life, it has not been least of the assurances that have sustained me in my own course of speciality of labor, that his views of social and economic theory have so nearly coincided with those which I have been led to form.

This general coincidence of doctrine is here offered as a reason for avoiding that indulgence in eulogy of his literary labors which so justly is their due. A still stronger reason for preferring to allow the simplest and plainest history of his works to indicate his worth, is found in that modesty which constituted so striking a feature in his character, respect for which forbids that I should here say of him anything that would have been unacceptable if said in his bodily presence. That I can entirely restrain within these limits the expression of my apprehension of his character, and of his life's work, I do not say; but that I feel the repressive influence of this regard correspondent with the habitual deference which has throughout many years of intercourse governed my demeanor towards him, is very certain. Further than this, however, it will be enough for praise if I can succeed in making this memoir an adequate report of his active and energetic life.

Having thus explained the feelings by which I have been influenced, I

shall now proceed to give such facts as have been attainable in regard to his unwritten history, and such indices of the works he has left behind him, as seem to claim a prominent place, and can be made to fall within the compass of the brief time allowed me for their presentation.

STEPHEN COLWELL was born in Brooke County, West Virginia, on the 25th of March, 1800. He died in Philadelphia on the 15th of January, 1871, having nearly completed his 71st year. He received his classical education at Jefferson College, Canonsburg, Washington County, Pa., where he graduated in 1819. He studied law under the direction of Judge Halleck in Steubenville, Ohio; was admitted to the bar in 1821; practised the profession seven years in St. Clairsville, Ohio; and in 1828 removed to Pittsburgh, where he continued so to do until the year 1836.

Indicative of that ability and industry which marked his whole subsequent life, and now so well accounts for the mass and quality of his attainments, are the facts that he graduated at the early age of nineteen, and entered upon his profession at twenty-one.

The practice of the law, however, was not the sphere of mental activity for which by tastes and talents he had been best by nature fitted. The study of this science was, nevertheless, a happy preparation for the inquiries in whose pursuit he afterwards became so much engrossed. Its exacter method, doubtless, corrected the mental habitude and the narrowing influence which an ardent mind is apt to catch from an exclusive devotion to the study of any single branch of literature or science. His writings everywhere bear witness in logic and diction to the corrective influence of his legal acquirements. Social science is that department of knowledge which especially receives its verification and practical adjustment in jurisprudence and civil goverment applied—the philosophy of Law being the crown and summary of sociology in all its branches.

Further, Mr. Colwell gave for a layman an unusual amount of study to the department of religious literature, and here also we find the guiding influence of his sociologic as well as of his legal training. A devoted religionist from earliest youth to the close of life, he gave himself to an ardent study of doctrine and of duty, meanwhile laboring as zealously and almost as constantly as if he had filled the office of pastor in the Church, in the propagation of such opinions as demanded conformity of life from professors of religion. His publications bear witness of his faithfulness, as his life in its every relation illustrated the morality and the charity which his faith enjoined.

It is not for us to sit in judgment upon religious doctrines, whether to applaud or to condemn them. His well known zeal, and his abundant labors in piety and charity, are here adduced for the simple reason that the portraiture of the man would be incomplete and most unworthy of its subject without distinct recognition of a feature so predominant in his character.

Were I here to venture an opinion, fully warranted perhaps by the subject, I should be disposed to say that the study of the theologian must

be greatly influenced for safer direction and better uses when held in logical harmony with, and restrained of its speculative tendencies by, those rules of thought which must govern men in the actual duties and relations of life. To my mind it is clearly obvious that the religious writings of Mr. Colwell exhibit a healthy tone and a useful drift reflected from his economic studies; and in these latter a faithfulness of service and a dedication of spirit and endeavor, which happily illustrate the moral responsibility resulting from the sentiments of the former. To this I may perhaps be allowed to add, that if each and every man occupying an influential position could be induced with equal fidelity and ability "to show his fidelity by his works," the prevailing indifference to the claims of Christianity would speedily give place to a widely different spirit induced by the attractiveness of its illustration. Here, however, I am engaged mainly with the prominent traits of Mr. Colwell's own character and the influences that formed his life and gave direction to it. His education and effective development were not found alone in the studies by which he was so largely and so usefully occupied. Whatever of principle and policy resulted from the application of the student was induced and enriched and energized in another and even more exact training school than any that the speculations of science can afford. In the thirty-sixth year of his age, fresh and full of all that reading and reflection could supply, he entered upon the conduct of business affairs in an occupation that as much as any other, and probably even more, brought into service and severely tested both economic facts and principles. He became a manufacturer of iron first at Weymouth, Atlantic County, New Jersey, and afterwards at Conshohocken, on the Schuylkill. Throughout a quarter of a century of vicissitudes, inflicted upon that department of manufacture more mischievously than upon almost any other by an inconstant and often unfriendly governmental policy, opportunity was presented, as the necessity was imposed, for studying the interests of productive industry in the light of such actual and greatly varied experiences as might instruct even the dullest, and could not fail to teach one already so well qualified for promptly understanding all that actually concerned that and every other branch of industrial production. Before entering upon the arduous and trying experiences of this pursuit he had visited Europe, and there had studied the art and management of its advanced and varied industries.

The settlement of the large estate of his father-in-law, the late Samuel Richards, and the administration of those of several other members of his family, required and received as much attention during many years as would have constituted the entire business of many men, who would have thought themselves fully occupied. In addition to private affairs, so considerable and so exacting, he was constantly engaged as a leading and working member of various public associations; industrial, benevolent and educational. The character, the extent and the variety of these engagements, to which he was invariably attentive and punctual, may be

inferred from a simple enumeration by their titles, as follows: he was a working member of the American Iron and Steel Association, from its origin to the close of his life; an active member of the African Colonization Society for more than a score of years; several years engaged in the management of our House of Refuge; nearly twenty years a Director of the Camden and Atlantic Railroad, whose Board of Directors, in a feeling notice of his death, say that, "having been an active member of the Board from its organization, and having contributed very largely of his means, time and labor in the prosecution and completion of this work; in many dark periods of this enterprise we could always look to Mr. Colwell for his matured judgment and able counsel."

He was a Director in the Reading and in the Pennsylvania Central Railroads, and for years held the office of a Trustee of the University of Pennsylvania; as also a similar position in the Princeton Theological Seminary. Simultaneously therewith, he was one of the Trustees of the Presbyterian General Assembly, and member of the Board of Education of the Presbyterian Church. After the close of the Rebellion he gave large pecuniary assistance, and his usual energy of service, to the Freedman's Aid Society, as during the Rebellion he had contributed with like liberality to the work of both the Sanitary and Christian Commissions. Of his services in these great patriotic charities a gentleman well acquainted with their history says: "At the breaking out of the Rebellion he felt deeply for the distress in the camps and on the battle-field, and it was at his suggestion that the first man who left his home to assist the helpless and the wounded, took his way to the seat of war. He also contributed freely to supply comforts to those in the hospitals. To one of the active stewards he said, 'Let nothing be wanting, and if the Government funds are insufficient I will see that the bills are paid.'" The same witness of his active benevolence to the suffering soldiers, and of his personal demeanor in its administration, further says: "Those who accompanied him on his visits to the Army of the Potomac, can never forget the kindness and respect with which he treated the humblest individuals."

In the patriotic services and sacrifices to which the country called its best citizens in the hour of its utmost need, he was in every form of duty, one of the earliest most constant, persistent and efficient of the men in private life who gave themselves unreservedly to the salvation of the Union. The Union League of this city in words which well might serve as a condensed memoir of his life and character, bears this testimony to his agency in the great work of their association: "With an intelligent and thoughtful mind, fully convinced of the necessity and usefulness of such an organization, and a heart warmly alive to the encouraging influences, it was peculiarly fitting that at the first formal meeting which led to the establishment of the Union League should be called upon, as he was, to preside. His name thus heads the list of signers of the constitution of the League; and he grew with its growth, ever in the forefront of whatever movement was planned for giving aid and comfort and

support to his country and its government throughout the course of its struggle for existence, in resisting, by force of arms, a causeless and wicked armed Rebellion." Of his personal character and demeanor, they say: "We desire to bear testimony to those virtues which manifested themselves in all its intercourse with us; to the singleness and unselfishness of his purpose; to his courteousness and urbanity in our varied relations; to his firmness, cautiousness and wisdom in the deliberations of our councils; to his patience, unwearying industry and cheerful devotion of time, abilities and means in aid of the cause so dear to all our hearts; to his constant unwavering joy, and faith, and trust in the overruling Providence of the God of our fathers amid the darkest hours of the country's peril, as well as in times of success and victory."

Such engagements as these, and numerous others kindred in their character and calling for similar labors, filled the middle and later periods of his life with occupation: his associates, and all with whom business intercourse and public enterprises connected him, testifying to the prompt, energetic, patient and worthy performance of every duty thus assumed or imposed. Nearly half a century employed in public and private affairs making large demands for labor and care, and involving great responsibility, gave him that sound practical experience which well and effectively woven into the studies of his life made him what he eminently became, a clear, safe, and thoroughly instructive economist. Concurrently with this practical training he was, in the best sense and fullest meaning of the word, a student. As early as his business life began, if not even earlier, he commenced the collection of a library of social science, political economy, finance, pauperism, organized charities, productive industries, and associate and cognate departments of science, now the largest and best to be found in the country. This grand collection has not been catalogued, or even classified, but it considerably exceeds five thousand volumes, and is estimated for the purpose of insurance at a value of twenty thousand dollars. To this library and to the books, pamphlets, periodical and newspaper articles of his own production, he devoted all his leisure. In several lists of cited authorities appended to his own publications and criticisms upon them, he furnishes evidence that he was, in the language of one of his familiar acquaintances, "one of the greediest of readers."

To the commonly accepted authorities on Political Economy, Finance, and Policy of Public Affairs, he, however, gave no more than that amount of faith and acceptance which they should command from a mind well stored with the facts and philosophy of their subjects. To a friend who expressed surprise at his vast collection of books and pamphlets on the single subject of Money, he replied when asked if he had perused them all, "enough to know that there is really little or nothing in them of any value."

His library, besides its completeness in standard works, derives a special value from its collection of over twenty-five hundred pamphlets on topics

usually embraced in what is called Political Economy; each separately bound and capable of classified arrangement. He regarded, and justly too, such smaller treatises as especially valuable for containing the best thoughts of the writers in the most condensed form, and likely thus to secure not only the greatest number but the most attentive readers. For the most part he put his own publications on social and economic subjects into this unpretending form.

His judgment was too clear and too well poised to suffer the imposture of pretentious authorship. Knowing that book-makers are not always thinkers he gave his regards to those writers only who had something of their own to say, or knew how to give effective array to the valuable words of others. It would have been an excellent service to students, now abandoned to their own unformed judgment in the selection of works in this department, and thus condemned to promiscuous reading, if Mr. Colwell had in some effective way employed his eminent discernment in giving us an *index expurgatorius* of the books and treatises upon economic subjects which crowd our libraries, thus driving a stake through the worthless and the false among them, numerous as the latter are. In his Essay Preliminary to List's Political Economy, he has, indeed, shown his eminent capacity for estimating aright the economic authorities of their true value, confining himself, however, almost entirely to an analysis and commendation of those works which are worthy of reliance. It was more consonant with his taste and tendencies to select the good, than to annoy himself with the study and exposure of that which was calculated to be injurious. Often have I wondered at the patience, even more than at the diligence, great as it was, with which he conscientiously surrendered so large a portion of his months and years to library labors. His toil, however, was made for excellent uses, and the fruits of his literary industry exhibit themselves not only in the number but also in the value of his publications. Of that value but little can be traced to the thousands of volumes which had passed through his hands. Indeed, it is curiously significant that the best read man in economic literature stands now before us so little indebted to the books of his predecessors for the most valuable portions of his own productions. Never writing without having something worthy to be read, all that he did write was, as largely as can be affirmed of any other prolific author, in matter and manner his own. There was in him, however, nothing of arrogance, nothing of the scorner. In the whole course of his literary pursuits may be discovered a constant effort to promote and propagate important scientific truths bearing upon social welfare, under cover of such books as seemed to him to deserve extensive circulation. To the translation, annotation, and effective distribution of these he freely and devotedly gave his time, his labor, and his means. Among the leading instances of this kind, is the translation, by Mr. Matile, of List's National System of Political Economy, with his own invaluable Preliminary Essay, above referred to, and with copious marginal notes upon the text, from his own pen. In like

manner he procured the translation (again by Mr. Matile) and the publication for liberal distribution, of Chastel's "Charity of the Primitive Churches;" and also the republication of "The Race for Riches," by William Arnot, of Glasgow, with a corroborative preface and notes, by himself supplied.

This would be the place for giving special attention to that long and varied catalogue of his own contributions to the literature of political economy, finance, charity, and Christian ethics, in the form of pamphlets and essays, and other articles in the reviews, periodicals and newspapers. With that detail, however, I will not here task myself nor use the passing hour of your time, preferring to append hereto a list of his works as full and complete as I have been able to make it. Mr. Colwell, as his family inform me, neither collected nor registered these productions, as a consequence of which my summary of them by their titles is necessarily incomplete, although not otherwise incorrect.

His labors of mind and pen, his endeavors, services, and subsidies in aid of the establishment and extension of collegiate education; his personal pressure upon all who were in the way of forwarding the great enterprise; his donations and legacies, all had this one grand leading aim—the propagation of sound doctrine in social duty, and its enforcement in the education not only of our scholars, but also of the reading people of our great community. To that object he dedicated his library in giving it to the University of Pennsylvania. Anxious to make the gift more effective, he coupled the grant, in his deed of trust, with a condition that required the endowment of a chair of social science; but his family, knowing his intention that the donation should in no event prove a failure, has waived the present performance of the condition, in the well warranted expectation that in good time it will be carried out.

With the like intent he labored long for the establishment of a professorship in the Theological Seminary of Princeton, an idea that, with the assistance of others in great measure brought to contribute by his own perseverance and his liberal advances, has now been carried into full effect. "His works do follow him"—the inauguration, on the 27th of September last, of a professorship of "Christian Ethics and Apologetics," in its promise fulfilling one of the dearest wishes of his heart.

What Mr. Colwell intended by the establishment of a chair of Christian Ethics, in Princeton, and what he regarded as the chief object of a chair of Social Science in the University of Pennsylvania, can scarcely be misunderstood if his own writings be studied for their ruling sentiment and leading purpose. Cultivating political economy as a theory of beneficence, he wrote his most elaborate and voluminous work upon the credit system, embracing therein all the agencies and instruments employed in foreign trade and domestic commerce, and gave a vast amount of time and thought to the literature of these several subjects in all their branches; but through all and over all the crowning aim and purpose of his endeavors stands out conspicuously, crystallized as it is in a definition of political economy in which, after reviewing the entire range of conflicting

explications, he says: "When we meet a definition running thus—the science of *human welfare*, in its relations with the production and distribution of wealth, we shall begin to hope the doctrine of social, or political, or national economy, is beginning to assume its proper proportions." The sentiment of that definition directed all his studies, all his writings, and, as a passion, governed all his life. In religion, the faith that *works* by love; in economic theory, the best interests of humanity; in morals, the justice, mercy, and charity which practically exemplify the brotherhood of men; were the governing impulses of all the works of both his head and his hands.

In his "New Themes for the Protestant Clergy" we find such sentiments as these: "Creeds, but not without charity; Theology, but not without humanity; Protestantism, but not without Christianity." Again: "It is not enough for the Christian to be concerned only for the interests of men in the world to come, but for their best interests in this world." With some severity of rebuke, but far more earnestness of affection, he says: "We maintain that Christ himself should have the chief voice in defining Christianity, and that this has been denied him in most, if not all, the compends and summaries of Christian doctrine which are the bond of Protestant churches;" following this up by urging the fact that "the world now believes that the religion announced by the Author and Finisher of our faith embraces humanity as well as divinity in its range."

This remonstrance, and its implied censure, will be understood when we perceive that he went further, far further, in his apprehension of true Christian charity, than almsgiving extended to pressing cases of distress. The modern usage of devolving the relief of the poor upon the poorhouse system established by the civil law, he calls "the stigma of Protestantism;" and he demands from the professors of Christianity an earnest endeavor to give the poor *permanent* emancipation from the evils which they endure. He presses the charge against the Established Church of England, that it holds resources donated to its Catholic predecessors for relief of the poor, which now yield £50,000,000 per annum, while throwing the support of the suffering upon the charity of the State; at the same time quietly sustaining that system of industrial and commercial policy which takes from the labor of the realm two hundred and fifty millions of dollars for the use of the government, and five times more for the profit of capital. Nay further this gentlest of gentlemen, this most orthodox of churchmen, this most devout of worshipers, in the conviction that the failure of Christians to exemplify Christianity in their dealings with the world is the grand cause of the aversion and rejection it encounters, is led therein to find some justification for the socialism and the insurrectionary demonstrations now so rapidly and threateningly spreading throughout Europe and America, and exhibiting such a spirit of revolt among the masses of Christendom as is nowhere found in the pagan world.

In the battle-cry of the reformers now advancing upon the conservatism of our civilization, he hears the proclamation of "the fatherhood of God and the brotherhood of man"—a protest against "that notion of individual liberty which leaves every man to care for himself, and ruin to seize the hindmost."

To the almost universally prevalent doctrines of political economy he traces the apathy, indifference, and even hostility of the fortunate classes to the duties enjoined in the second table of the law, as it is summarized by the Great Teacher. Singling out the most distinguished and most popular of now existing disciples and advocates of the *laissez-faire* school of economists, he thus exhibits Herbert Spencer's "Social Statics": "The man of power and the man without; the man of wealth and the pauper, should each have the largest and most perfect liberty consistent with their not touching each other. * * * It forbids the thought of charity, or brotherhood, or sacrifice; it consecrates selfishness and individualism as the prime feature of society. * * * Its principle is the least possible restriction, the fewest possible enactments; the weak must be left to their weakness, the strong must be trusted with their strength, the unprotected man must not look for favor, and government must resolve itself into the lowest possible agent of nonintervention."

Than the view thus presented of the now-so-much lauded Spencerian social philosophy nothing could be more thoroughly accurate. The whole tendency of that modern economical school, to whose teachings our departed friend was so much opposed, has been, and is, in the direction of giving increased power to the rich and strong, while throwing responsibility on the shoulders of the poor and weak. "If the latter *will* marry, and *will* have children, why," say they, "should they not be allowed to pay the penalty of their crime, as so many millions of starving Irish have already done?" "Why," though in somewhat different words, now asks Mr. Spencer, "Why should not the poor remain in ignorance if unable to provide for educating their children and themselves?" "Why should the millionaire be required to aid in maintaining hospitals in which damage to poor laborers' limbs may promptly and properly be repaired?" "Is it not for every man to do as he will with that which is his own?" The new philosophy having answered this latter question in the affirmative, need we be surprised that the miserable selfishness thus given to the world as science should have excited the indignation of one who knew, and felt that it must be a mere pretence of science that could sanction any course of conduct so wholly inconsistent with the divine command, "that we do to others as," under similar circumstances, "we would that they should do to ourselves?" Assuredly not!

It would be difficult for me fully and completely to express the strength of the humanitarian sympathies exhibited in Mr. Colwell's plea for justice to the victims of our reckless competition and our voracity in the pursuit of material wealth. To prevent misconstruction of his severe animadversions upon the existing agency of church and state in the prevailing disorders of society, and to show the bearing of his complaint I

cite another passage from the "New Themes," as follows: "The doctrine that property, real and personal, must under all circumstances remain inviolate, always under the ever-watchful vigilance of the law, and its invaders subject to the severest penalties of dungeon and damages, may be very essential to the maintenance of our present social system, but it totally disregards the consideration that Labor, the poor man's capital, his only property, should, as his only means of securing a comfortable subsistence, be also under the special care and safeguard of the law. The doctrine that trade should be entirely free—that is, that merchants should be perfectly at liberty, throughout the world, to manage their business in that way which best promotes *their* interests—may suit very well for merchants, making them masters of the industry of the world; but it will be giving a small body of men a power over the bones and sinews of their fellow-men, which it would be contrary to all our knowledge of human nature if they do not fatally abuse, because they are interested to reduce the avails of labor to the lowest attainable point, as the best means of enlarging their business and increasing their gains. That philosophy," he continues, "which teaches that men should always be left to the care of themselves—that labor is a merely marketable commodity which should be left, like others, to find its own market value without reference to the welfare of the man, may appear plausible to those who forget the fatherhood of God and the brotherhood of men, but is utterly at variance with the precepts of Him who taught that those who stood idle in the market-place because no man had hired them, and were sent to work at the eleventh hour, should receive the same as those who had borne the burden and heat of the day."

It is not my business here and now either to commend or to impeach, but simply to state the attitude assumed by Mr. Colwell in reference to questions so much exposed to debate as these, and by him so sharply and earnestly treated. The great sensation produced in our religious world by their publication has given way to much more moderate feelings, and evidently enough to a better appreciation of their spirit and design. One of the representative papers of the church of which he was a life-long member, thus speaks of the controversy which his publications had aroused ten years since: "In one or two of his own books on this engrossing and all-important theme [Christian charity], he used language in regard to the apathy and criminality of modern professors of faith in Christ and his salvation, which was so severe as to arouse bitter hostility to his faithful and well-meant efforts. Would that now, when the mutual wounds have ceased to smart, in the case of most of those engaged in them, alas! by a departure from all the conflicts of the church militant, earnest men could be roused to examine their lessons and suggestions, forgetful of the occasional sharpness of the form in which they were conveyed." The most aggrieved having thus now come to acknowledge that "faithful are the wounds of a friend," they may also recollect that only once, and that in a strikingly pertinent instance, the founder of their faith is reported to have

given way to indignation against a piety that subordinated humanity to theology. "When the rulers of the synagogue watched him whether he would heal the withered hand, in their church, on their Sabbath-day, he looked round about on them with *anger*, being *grieved* for the hardness, or, as the margin has it, the blindness, of their hearts." (Mark iii. 2–5). That it was this sort of indignation, mixed with the same kind of grief, which induced the severity of remonstrance complained of at the time, is manifest in the whole tone, and yet more so in the special drift of his objurgations. The true construction of his aim, indeed, is found in his protest against the ruling doctrines of political and social economy which the churches, in common with the community, accept. A single sentence well represents him on this subject, as follows: "The social, political, and commercial institutions of the present day, founded upon, and sustained by, a selfishness heretofore unequaled, are the great barriers to the progress of Christianity." And again: "Political economy, strictly so called, is as much opposed to the spirit of Christianity as it is antagonistic to socialism; or, in other words, there is far more in common between socialism and Christianity than there is between the latter and political economy." The system of economic theory by himself adopted, is of course not the one intended here, but is that one which, referring to the North British Review, is thus described: "Followed out to the utmost, the spirit of political economy leads to the fatal conclusion—that the conduct of the social life should be left entirely to the spontaneous operation of laws which have their seat of action in the minds of individuals, without any attempt on the part of society, as such, to exert a controlling influence; in other words, without allowing the State or institutions for general government any higher function than that of protecting *individual* freedom."

It is, therefere, the *laissez-faire* theory of political economy which thus is charged with hostility at once to Christianity and humanity. The buy-cheap-and-sell-dear system elsewhere described by him as a policy "in trade and in society, which makes it not only the interest, but the natural course of every one to prey upon his fellow-men to the full extent of his power and cunning, and is well fitted to carry selfishness to its highest limits, and to extinguish every spark of mutual kindness." His political economy was a system of philosophic benevolence, a doctrine of justice, mercy, and truth, with a resulting economic policy of protection to productive industry, leading to the highest human welfare. In the appendix and notes to his second edition of the "New Themes," he has given us a whole library of the literature of Charity. In the hundreds or treatises there cited and briefly epitomized, he exhibits a breadth of survey and depth of inquiry that one would think must exhaust the subject. It was the result of many years of labor, directed by a zeal that nothing could inspire and sustain but a heartfelt devotion to the work of social duty and remedial beneficence. May I not here add, as a reflection that concerns the students of social science, that the system of economic doctrines which secured the assent of a mind so fully informed, so eminently

endowed, and so long and zealously devoted to a search after truth, is entitled to all the confidence that authority can give, and justly claims most studious attention.

Having rendered his best personal services to the subject which he had so much at heart, he further evidenced his earnestness and solicitude for its still more formal and more adequate treatment by offering a prize of $500 for a treatise upon the law or doctrine of Christian charity, accompanying the offer with a general outline directory of the plan of the required work, indicating its essential points; among which are to be noted the organization of labor; international trade in its effects upon the rewards of domestic labor; the subject of public education; the law of charity as applying to the poor, the suffering, the imprisoned, the vicious, the insane, the intemperate, the dangerous, &c., &c.

I am not aware that any work of real merit was secured by the liberal reward offered. No such book having been published, it is presumable that no response was made.

There remains yet to be considered, in such manner as my limits allow, another and a highly important division of the service rendered to the public by Mr. Colwell, in an official position to which his high reputation called him in the 65th year of his age. In June, 1865, he was appointed upon the Commission, authorized by Act of Congress, "to inquire and report upon the subject of raising by taxation such revenue as may be necessary in order to supply the wants of the government, having regard to, and including the sources from which such revenue should be drawn, and the best and most efficient mode of raising the same." In the service imposed by this appointment he continued till the midsummer of 1866, when the work assigned was finished and fully reported. The labor thus undertaken and performed interrupted and even ended the active literary pursuits and practical work of his life. His family, whose tenderly affectionate watchfulness makes them the best and most competent witnesses, attribute to his exacting and exhausting toil in the duties of this position that failure of his health which soon afterwards obliged him to relinquish, in great measure, his life-long pursuits both as student and as writer.

In the Report of the Revenue Commission, communicated to Congress in January, 1866, and published in a large octavo volume by authority of the House of Representatives, may be found the special reports of Mr. Colwell on "The Influence of Duplication of Taxes upon American Industry—upon the Relations of Foreign Trade to Domestic Industry and Internal Revenue—upon Iron and Steel—and on Wool and Woolens." Two other reports of his, one upon High Prices and their Relations with Currency and Taxation, and another, upon Over-importation and Relief, are not included in this volume. How he executed the work which fell to his share of the duties of the Commission, it is enough to say that *he* did it to assure us of finding therein the fullest discussion of those vastly comprehensive subjects, based upon the most ample store of statistical facts, and arrayed with that force which the soundest theoretical princi-

ples, and the largest practical acquaintance with the details which enter into the several subjects of inquiry, alone could give.

The work done by him, outside of that which his own pen has reported, was of itself, and independently, worthy of permanent record. The Secretary of the Wool Manufacturers' Association, Mr J. L. Hayes, an eminently capable witness, thus speaks of his agency and influence in harmonizing the conflicting interests of the agriculturists and manufacturers of this staple industry of the nation: "The conferences between the two committees (representing the respective parties) commenced in January, 1865, and were continued without much pause for six months. At the outset the two committees were widely apart in their views, and the traditional jealousies became at once apparent. Here the weight of character disinterestedness, and moral power of Mr. Colwell came into play. He was personally present at many of these conferences, and I am convinced that the harmonious arrangement finally made was mainly due to his influence. This influence was perfectly unobtrusive, but both parties had absolute reliance upon Mr. Colwell's integrity and wisdom, and a mere hint from him was sufficient to give a right direction to our councils. Some of the suggestions which he made were of great practical value." Of one of these this gentleman says: "It has been in operation five years, and it is a constant surprise to manufacturers and growers that so brief an act, affecting so many really distinct branches of industry, should cover so much and operate so wisely." Again he says: "The bill, of which the chief features are due to Mr. Colwell's suggestions, is wonderfully sustained; its practical working is really remarkable for its success, * * * but the influence upon our own industry is by no means the chief object. The wool tariff is the key to the protective position in this country. It secures the agricultural interest and the West."

His treatment of this subject, and the reports upon trade, production, prices and national finance, place him, in my judgment, highest among the authorities in our history in whatever combines knowledge of facts and soundness of economic principles. Quite sure am I that there is not so much of practical value and guiding principle to be learned even in that great storehouse of economic literature which he has given to the University. The earnest and intelligent student of the industrial and commercial policy of our country who may give to these reports the attention that is their due, will find himself prepared for a safe, clear and satisfactory judgment upon all of the many questions therein embraced.

Incidentally, but necessarily, intermixed with the history and statistics of our national industries, an unusually effective examination of the theories of free trade and protection finds a deservedly prominent place in these reports; and the predominant claims of labor upon the care of government and the regard of the community is the pervading spirit and ruling impulse of all that he here has written. His heart was in this matter, and his philosophy most happily corroborated his philanthropy. The key to all his economic doctrines is in such simple self-proving propositions as these: "The highest condition of national welfare depends upon

the highest condition of the masses of the people in point of morals, religion, intelligence, social ease, and comfort." "The industry of a nation is an interest so vital as to be equaled only by its internal liberties and its independence of foreign control. As the tendency of full employment is to exclude crime, the benefits of that high integrity which is the best cement of society, may be expected to reward a nation in which occupation is the most varied and labor best remunerated."

Last to be noticed, although not latest in its presentation to the world, is Mr. Colwell's highly valuable work on money and its substitutes, credit and its institutions, entitled, "*Ways and Means of Payment: a full analysis of the credit system, with its various modes of adjustment.*" Its essential object is that of laying the axe to the root of that pestilent heresy which teaches that prices are wholly dependent on the supply of money; and that, to use the words of Hume, the only effect of an increase in the abundance of the precious metals is that of "obliging every one to pay a greater number of those little white or yellow pieces than they had been accustomed to do." The whole question of prices is here discussed with a care characteristic of its author; and his readers, however they may chance to differ from him in regard to details, can scarcely fail to agree with him in the belief he has here expressed, that "among the innumerable influences which go to determine the general range of prices, the quantity of money or currency is found to be one of the least effective." Truth, however, as is well known, travels but very slowly through the world, centuries having elapsed since demonstration of the fact that the earth revolved around the sun, and four-fifths of the human race yet remaining convinced that the sun it is that moves, and not the earth. So has it been, and so is it like to be, in the present case, the most eminent European economists still continuing to teach precisely what had been taught by Hume, and statesmen abroad and at home still constructing banking and currency laws under the belief that in the "quantity of money or currency" had been found one of the *most* effective causes of changes of price. Mr. Colwell's work was published in 1859, since which date so much light has been thrown on the subject as to make it serious cause for regret that his other engagements, and his failing health, should have prevented a re-examination of the case by aid of recent facts, all of which have tended to prove conclusively the accuracy of the views presented in the very instructive volume to which reference has now been made.

A word more and I shall have done. Of all the men with whom I have at any time been associated there has been none in whom the high-minded gentleman, the enlightened economist, the active and earnest friend to those who stood in need of friendship, and the sincere Christian, have been more happily blended than in the one whose loss we all so much regret, and of whose life and works I here have made so brief, and, as I fear, so inadequate a presentation.

List of the Published Writings of Stephen Colwell.

1. Letter to the Pennsylvania Legislature on the removal of the Deposits from the United States Bank. 8vo. pp. 45. 1834.
2. The Poor and Poor Laws of Great Britain. Prince. Rev. Jan. 1841.
3. Review of McCulloch's British Empire. Prince. Rev. Jan. 1841.
4. The Smithsonian Bequest. Princeton Review, 1842.
5. Sweden, its Poor Laws and their bearing on Society. P. R. 1843.
6. In and Out of the County Prison. No date.
7. The Relative Position in our Industry of Foreign Commerce, Domestic Production, and Internal Trade. 8vo. pp. 50. 1850.
8. Memorial to Congress in relation to Tariff on Iron. 8vo. pp. 16. 1850.
9. New Themes for the Protestant Clergy, with Notes on the Literature of Charity. 12mo. pp. 384. 1851.
10. New Themes for the Protestant Clergy, with Notes on the Literature of Charity. Second Edition. 12mo. pp. 384. 1852.
11. Politics for American Christians. 8vo. 1852.
12. Money of Account. Merchants' Magazine. pp. 25. April, 1852.
13. Hints to a Layman. 12mo. 1853.
14. Position of Christianity in the United States, in its relations with Our Political System, and Religious Instruction in Public Schools. 8vo. pp. 175. No date.
15. Preface and Notes to The Race for Riches 12mo. pp. 54. 1853.
16. The South: Effects of Disunion on Slavery. 8vo. pp. 46. 1856.
17. Preliminary Essay and Notes to The National Political Economy of Frederick List. 8vo. pp. 67. 1856.
18. Money of Account. Bankers' Magazine. pp. 25. July, Aug. 1857.
19. The Ways and Means of Payment. 8vo. pp. 644. 1859.
20. Money, the Credit System, and Payments. Merchants' Mag. 1860.
21. The Five Cotton States and New York. 8vo. pp. 64. 1861.
22. Southern Wealth and Northern Profits. 8vo. pp. 31. 1861.
23. The Claims of Labor, and their precedence to the Claims of Free Trade. 8vo. pp. 52. 1861.
24. Gold, Banks, and Taxation. 8vo. pp. 68. 1864.
25. State and National System of Banks, the Expansion of the Currency, the Advance of Gold, and the Defects of the Internal Revenue Bill of June, 1864. 8vo. pp. —. 1864. [1866.
26. Upon High Prices and their relations with Currency and Taxation.
27. * Influence of the duplication of Taxes on American Industry. 1866.
28. * Relations of Foreign Trade to Domestic Industry and Internal Revenue. 1866.
29. Over-importation and Relief. 1866.
30. * Iron and Steel. 1866.
31. * Wool and Manufactures of Wool. 1866.
32. Financial Suggestions and Remarks. 8vo. pp. 19. 1867.

Reports made from the Revenue Commission :—Those marked with an asterisk published in the Reports of the Committee.

Observations on the distribution of certain Extinct Vertebrata in North Carolina.

By Edward D. Cope.

(*Read before the American Philosophical Society, November* 17, 1871).

Diodon L.

Diodon antiquus, Leidy. Proc. Acad. Nat. Sci.

Superior and inferior jaws from the Miocene. This fish was described from transported and much worn specimens from the Ashley River, South Carolina. The present specimens are unworn, and display the characters of the species. These are very much like those of the recent *D. filamentosus.* The species appears also to pertain to the horizon of the Miocene.

Belodon, Myr.

Teeth of both the smooth and fluted types were found by Prof. Kerr in Chatham Co., N. C. The latter (*B. carolinensis*, Emm.) appear also to occur in Wheatley's collection, from the Trias of Phœnixville, Penn. Three successive forms of the maxillary teeth of *B. priscus* are figured.

Thecachampsa, Cope.

Thecachampsa rugosa, Emmons.

Polyptychodon rugosus, Emmons, Geol. Surv. N. C.

Emmons' figure of this species is not distinguishable from a worn canine of a *Basilosaurus*, and as such I regarded it on a former occasion. An examination of a specimen received from Prof. Kerr, shows that its affinities are Crocodilian, and its structure similar to that of *Thecachampsa*, Cope. It is more strongly rugose-striate than in any of the known species, but is approached in rugosity by *Thecachampsa squankensis*, Marsh. The range of the genus is thus extended to N. Carolina.

Clepsysaurus, Lea.

Teeth of this genus are very rare, one only having been observed by Dr. Lea. Prof. Emmons believed that he had discovered two species in the Trias of North Carolina, *C. pennsylvanicus* and *C. leaii.* The greater part of the remains on which these were based I have shown to be Belodonts, but one tooth figured by Emmons, N. C. Geol. Surv., Pl. V. f. 3, may belong to this genus.

Prof. Kerr's collection contains two teeth which are identical with that associated with the *C. pennsylvanicus* by Lea, one of them nearly perfect, the other the basal portion only. They exhibit two minutely denticulated cutting edges, separated by one-third of the circumference. This third is nearly flat, the remaining portion being very convex. One cutting edge extends to the base of the crown, the other occupies only the distal two-thirds. The section of the tooth would be round at the base were it not for the projection of the cutting edge. The enamel is minutely striate, under the glass. The base of the larger tooth measures .75 of an inch in diameter. The figure of Emmons leaves something to be desired, as he

does not represent the long cutting edge of the crown. His descriptions of the tooth appear to refer to this genus. Kerr's specimens are conclusive as to the extent of this formidable genus of carnivorous Dinosauria to N. Carolina.

ZATOMUS, Cope.

This genus embraces reptiles whose teeth are described and figured by Prof. Emmons, American Geology, Pt. VI. p. 62, fig. 34. He found them associated with radiate osseous plates (probably dermal) which he found on one occasion in connection with the cranium of the supposed Labyrinthodont, *Dictyocephalus elegans*, Leidy. Both the plates and teeth are too large to be associated with the latter, and the teeth especially remind one of the *Dinosauria*. Emmons describes a tooth in the following language:

"It is compressed, curved, finely serrate posteriorly, which appears to point to the apex, when seen so as to bring into view a slight wrinkle or groove at the base of each tooth. Its enamel covers the whole crown, or all above the part implanted or inserted. The enamel is finely or minutely wrinkled, and at the posterior edge, at the junction of the plates at each side, a faint groove remains; and the serræ appear like a double row, but near the apex they entirely disappear; the convex or anterior edge is smooth.

"The tooth appears much like the tooth of a *Megalosaurus* in miniature, though it is less curved. I have found only two teeth of this kind: the smallest is half the size of the one figured." This size is 0m. 022 in length; diameter at base .012.

In the section given by Emmons, one side of this tooth is a little more convex than the others.

The affinities of this genus appear to be to *Teratosaurus* and *Lælaps*. From both of these, as well as from *Megalosaurus*, it differs in the absence of serration from the anterior margin, and in the groove in the posterior cutting edge dividing it into two appressed serrate edges which disappear near the apex. The species may be called *Zatomus sarcophagus*. Its size about equalled large specimens of the Southern Alligator.

HYPSIBEMA, Cope.

Char. gen. Proportions of limbs and feet much as in Hadrosaurus. The caudal vertebræ elongate and depressed, in the median part of the series.

The elongate depressed form of caudal vertebræ, distinguishes this genus from Hadrosaurus. The latter possesses elongate vertebræ near the extremity of the series, but anterior to this point, they are first subquadrate in profile, then proximally much narrowed. The form exhibited by the known species of this genus is more like that of Hylæosaurus Mant.

HYPSIBEMA CRASSICAUDA, Cope.

The remains on which this species is founded consists of the distal extremity of the right humerus, a portion of the shaft of the left tibia, a

portion of the fibula, the right internal metatarsus somewhat broken, and a caudal vertebra. There are other uncharacteristic fragments, and a piece which may be a dermal bone.

Associated with them are several coprolites of large animals.

These species indicate an animal of about the size of the Hadrosaurus foulkei, Leidy, and with a similar disproportion in the lengths of the limbs.

This is readily appreciated on comparison of the huge metatarsus with the light humerus. The medullary cavity of the tibia is large; that of the humerus small.

The portion of the humerus preserved is injured, and the condyles are worn. Its relation to that of H. foulkei is readily determined, and on comparison the following marked differences appear: The ridge connecting the external condyle with the shaft posteriorly is acute; it is rounded in H. foulkei. External distal face is flat or slightly concave; in H. foulkei somewhat rounded. It is at right angles to the plane of the anterior face, and forms with it rather less than a right angle; in H. foulkei this region is rounded. Distally, the shaft is much flattened in H. crassicauda.

Measurements.	*Lines.*
Antero-posterior diameter of shaft, just above condyles....	20.5
Width external face distally....	24.
" olecranar fossa....	16.
" condyles, (estimated)....	64.

The anterior face at over three inches above the condyles is slightly concave. About 4.5 inches above the articular face of the external condyle, the acute ridge dividing the posterior and external faces disappears, and the surface becomes regularly rounded.

The portion of the tibia is from the shaft of that of the left side, just below the superior antero-posterior expansion. Therefore, the inner face is the most extensive, and the posterior the least so. It differs from the same part in H. foulkei, in its less angularity, especially in the more rounded, and less defined posterior face.

The internal face narrows downwards, and while the greater diameter of the fragment above is antero-posterior, below it is diagonal, the anterior point being the inner.

Measurements.	*Lines.*
Antero-posterior diameter above....	48.
Transverse " "	22.5
" " medullary cavity....	20.5

The portion of the fibula is the distal, and resembles that of Hadrosaurus foulkei, in being slightly expanded near the extremity, and cylindric in the lower part of the shaft. In both genera and Ornithotarsus, Cope, the distal extermity of the fibula is less attenuated then in Iguanodon.

	Lines.
Transverse distal diameter.	40.5
" five inches above	30.

The right internal metatarsus also bears considerable resemblance to H. foulkei. Its proximal extremity is much more convex in its inner outline than in that species. The inner proximal face is plane and longitudinally wrinkled. The proximal or tarsal articular face is concave anteriorly ; its plane is at right angles to the axis of the shaft of the bone. It is strongly oblique in H. foulkei, and a rib-like prominence of the outer face crosses the latter obliquely and at right angles to the proximal extremity. No such rib exists in the present case, because the weight was supported by the shaft of the bone, directly and not obliquely as in Hadrosaurus. Thus the Hypsibemas walked more exactly on the toes than did the Hadrosauri.

The posterior margin is thinner, and as in H. foulkei, presents a rather small median protuberance. The distal condyle is broken away, but the twist of the distal portion of the shaft shows that it was directed away from the adjoining metatarsal, posteriorly.

Measurements.	*In.*	*Lines.*
Length from antero-superior to postero-inferior,	10	10
Extremity (inferior articular face worn away),		
Traverse diameter proximally	3	
" " medially	2	3.5
Antero-posterior diameter medially	3	6.

The diameters of the shaft are somewhat larger than in the H. foulkei given by Leidy.

The caudal vertebra is of large size and peculiar form. The centrum is considerably wider than deep, and considerably longer than wide. The posterior chevron articulations are small, and each is connected with each anterior by a strong rounded angulation. Between the latter the space is wide and slightly concave in transverse section, least so medially. A marked peculiarity is seen in the strong longitudinal ridge which divides the lateral surface of the vertebra into two nearly equal faces. The neural arch is elongate, the neural canal small: in section a short vertical ellipse. The articular face of the zygapophyses makes an angle of about thirty-five degrees to the perpendicular. The crest of the arch rises a half inch behind these into the very stout basis of the neural spine, the greater part of which, with the posterior zygapophyses, is broken off. The inclination of the base is about 65° to the vertical diameter of the bone. The articular faces are both slightly concave, as are the lateral faces which are separated by the lateral ridge.

	In.	*Lines.*
Length of centrum	4	6
" basis of neural arch	2	9
Width posterior articular face	4	

		In.	Lines.
Depth " medially		2	8
" " laterally		3	3
" basis neural spine			12
Transverse diameter neural canal behind			10
Width between latero-inferior ridges		1	9
" vertical face of zygapophyses			11

There is a slight rugose protuberance in the position of the diapophysis.

The peculiarities of this vertebra indicate most strikingly the generic distinctness of this great reptile from the Hadrosaurus. It is true it presents some similarity in form to the terminal caudals of that genus and if it could be referred to that portion of the series, would indicate merely another and larger species of Hadrosaurus. It differs in form from these vertebræ, in its depressed instead of compressed form, and its lateral angulation. That it belongs to a more anterior position in the tail is evident from the very large size of the basis of the neural spine, and general greater development of the neural arch and zygapophyses, and the trace of diapophyses. Further, it is over four times the size of the terminal caudals of H. foulkei, while the remaining elements do not indicate any such extraordinary dimensions. A position a little behind the middle of the series would relate well to the other proportions.

This is another of those remarkable forms which the reptilian type developed in past ages. That it was herbivorous, and relied less on its tail for support than Hadrosaurus, appears probable. Large caprolites of the character of those of herbivorous animals accompanied the bones. They resemble somewhat those of the hog ; one has a diameter of 3.5 inches one way, and 2 inches the other; extremity broad, obtuse. The proprietor of the pit told the writer that he had more than once seen large "hoofs" "and wide toe-joints" taken out during the excavation.

This species is different from the Ornithotarsus immanis, Cope, and belongs to a different genus. The shaft of the tibia in the latter is filled with cancellous tissue ; in the present animal it is entirely hollow.

From the marl pits of James King.

HADROSAURUS, Leidy.

HADROSAURUS TRIPOS, Cope.

At a point about ten miles distant from the marl pit in which the Hypsibema was found, Prof. Kerr discovered a caudal vertebra of a colossal reptile, whose affinities are evidently near to the Hadrosaurus foulkei.

This vertebra is one of the distal, as evidenced by the entire absence of any trace of diapophysis, and its subquadrate longitudinal section, as well as by the small size of the neural arch and spine. At first sight it would appear to occupy a position between the thirtieth and thirty-sixth of the series; the former in H. foulkei has, however, rudiments of a diapophysis. Both its articular faces are distinctly biconcave. The large

size of the chevron articular face is as in the thirtieth, and the concavit of its lateral faces as in the twenty-sixth; in the thirty-sixth the side are entirely plane. The round form of the neural canal, as well as lac of diapophysis, are points of resemblance to the thirty-sixth, but it i more than twice as long as that vertebra in the H. foulkei. In the thirtiet the neural canal is somewhat depressed and becomes more so as w advance towards the proximal part of the series. The small antero-pos terior extent of the neural arch is much as in the thirtieth in H. foulke but the basis of the neural spine, which is broken off in this, as well a the odd species, is much more slight. It is so very thin and weak as t indicate either comparatively a slight development of the spine, or very posterior position in the series. A weak lateral ridge marks the sid of the centrum, which is below the middle line. It holds the same positio in the thirty-sixth in H. foulkei, but is above the middle in the thirtiet and those anterior.

Measurements.	*In.*	*Lines.*
Depth centrum to summit chevron articulation..	5	
" from neural canal without chevron face...	4	
Greatest width " " " ...	4	9
Length centrum..........	4	3
" neurapophysis	2	6
Width between anterior zygopophyses...........	1	3
" of arch above.........................	1	6
" neural canal............................		10
Depth "		10
" basis neural spine......................		5

This specimen was procured from the marl pit of W. J. Thompso Sampson Co., N. Carolina.

A second and much smaller vertebra from the pit that furnished tl remains of Hypsibema crassicauda, belonged to a third individual, ar possibly to this species. Its proportions would point to a position ne the end of the tail, and its form is less elongate and compressed th those in that position in H. foulkei. Its neural arch is not coössified. Tl extremities are slightly concave, the general form subquadrate.

	Lines.
Length of centrum..................................	20.5
Diameter extremity, (vertical).........................	18.
" " (transverse).......................	21.5
" middle "	15.

The first named vertebra pertained to an immense species, perha double the Hadrosaurus foulkei, in weight and bulk, should the gener proportions of the two have been at all similar. In that case the leng of the femur would be sixty-two and a quarter inches.

It will remain for future discovery to determine whether the species the same as the Ornithotarsus immanis.

PLATE I.—*Hypsibema crassicauda.*

1. Caudal Vertebra of Hadrosaurus tripos, side. 1a. Articular face.
2. do. young? a. end, b. below.
3. Eschrichtius polyporus, side. 3a. above.

PLATE II.—*Hypsibema crassicauda.*

1. Humerus, distal portion, from below. 1a. From end.
2. Tibia shaft, from the side; 2a. from end.
3. Caudal Vertebra.
4. Coprolite fragment.

PLATE III.—*Hadrosaurus tripos. Eschrichtius polyporus.*

1. Fibula, lower portion; a. proximal end of fragment.
2. Outer metatarsal, inner side; 2a. proximal end of do.

PLATE IV.—*Mesoteras kerrianus. Clepsysaurus pennsylvanicus. Thecachampsa rugosa. Polydectes biturgidus. Belodon priscus. Diodon antiquus.*

1. *Mesosteras kerrianus*, periotic bones. 1a. Interior view; 1b. end view.
2. *Polydectes biturgidus*, crown of tooth, side; 2a. inner view.
3. *Thecachampsa rugosa*, crown of tooth, inner view.
4. *Clepsysaurus*, tooth, inside view; 4a. posterior view; 4b. section base; 4c. do. near extremity; 4d. base of larger sp.
5. *Belodon? priscus*, anterior tooth; 5a. posterior view of another; 5b. lateral view of a posterior tooth; 5c. edge of do.
6. *Diodon antiquus*, upper jaw front; 6a. do. from below; 6b. lower jaw from front; 6c. do. from above.

Stated Meeting, December 1, 1871.

Present, ten members.

DR. EMERSON in the Chair.

A letter of acknowledgment (86) was received from the Society of Antiquaries, dated London, November 8.

Letters of envoy were received from the Pontifical Academy d. N. L., dated Rome, June 7, 1869; and from the Public Museum, at Buenos Ayres, dated July 12, 1871.

A letter was received from Mr. H. H. Leech, dated New York, Nov. 18, 1871, offering for sale the MSS. Fables of M. Lorin, of Paris.

Donations for the Library were announced, from the P. A. d. N. L. at Rome, the R. Institutes at Milan and Venice, the R. Observatories at Moncaliere and Turin, Signori Dorna, Biffi, Muoni, Buccellati, Ferraris, Gabba, Mussi and Denza; from the Public Museum at Buenos Ayres; the Editors of the Revue Politique, Old and New, the American Chemist, and from Yale College.

A photographic copy of the quasi coin described below, was presented to the Cabinet by Mr. Dubois.

An Obituary notice of Sir John F. W. Herschel, written by Mr. H. W. Field, of the Royal Mint, London, pursuant to appointment, was read by Mr. Patterson.

Obituary Notice of

SIR JOHN FREDERICK WILLIAM HERSCHEL, BART.,

BY MR. HENRY W. FIELD, OF LONDON.

Read before the American Philosophical Society, December 1, 1871.

It is the painful duty of our Society to record the loss we have sustained in our membership, and indeed we may well say, the loss to the world in general, by the decease of the illustrious Sir John F. W. Herschel, Bart.

His father, Sir William Herschel, came from Hanover to England, in 1759, as one of the Hanoverian Guards' Band; and was for some time the subject of disappointment and privation. He however became instructor to a regimental band, stationed in the North, and fortunately obtained an organist's appointment in Yorkshire, and subsequently at Bath. Here it was that his taste for astronomy became developed, and from whence his first papers, "Observations of the Periodical Star Mira Ceti" issued. They were read before the Royal Society, in London, on the 10th May, 1780.

In 1781, the results of his studies and speculations led to his great discovery of Uranus (specially interesting from its leading to the discovery of the remote planet Neptune) which placed him most prominent in Scientific rank, which standing he retained until his death in 1822, being then in his 84th year.

Mr. Herschel, our lamented member, (unlike his father who raised himself from the humble rank of a regimental musician) after being educated privately by a Mr. Rogers, at an early age entered St. John's College, Cambridge, where by his great success and taste for science he graduated B. A. in 1813. He came out in the Mathematical Tripos, Senior Wrangler; an honor which was further enhanced by his attainment of the Fir s Smith's Prize. That his year was what is called, in Cambridge, "a good year," is evident from the names of the distinguished men of whom he took precedence, such as the following:—Peacock, Dean of Ely; Fallows, late Astronomer Royal at the Cape; Romilly, late Registrar of the University; Amos, Mill, and other men of note, whose names adorn the Det partments of Science, Theology and Literature. It may be worth while to note the feeling which subsisted among his fellow collegians; Charles Babbage, the mathematician (lately deceased) who coveted the honor of of Senior Wranglership, but knowing the powers of his antagonist, Herschel, declined to appear in the Mathematical Tripos, choosing rather to be at the Head of the Poll.

On the 27 May, 1813, he was elected Fellow of the Royal Society, and became one of its most active members, receiving in 1821 the Copley medal.

At his father's death he pursued that branch of science called "Observing Astronomy," and about this time he conceived the desirability of forming a Special Society, and was most active in its foundation, the present "Royal Astronomical Society."

In 1831, King William, as a tribute to his great scientific services conferred on him the honor of knighthood.

Sir John Herschel's researches on the positions of Nebulæ and clusters of stars, took up many years of his life. Several of the results he published in conjunction with Mr. (after Sir James) South, for which a reward of a gold medal was presented to both Astronomers. Were it not for the sincere love of science, the toil of these proceedings from midnight to sunrise would not have taken place; for no one can tell the strain on the constitution, the severity of which is gleaned from his observations while discussing the double stars. He remarked :

"Should I be fortunate enough to bring this work to a conclusion, I shall then joyfully yield up a subject on which I have bestowed a large portion of my time, and expended much of my health and strength, to others who will, hereafter, by the aid of those masterpieces of workmanship, which modern art places at their disposal, pursue with comparative ease and convenience an inquiry which has presented to myself difficulties such as at one period had almost compelled me to abandon it, in despair."

In 1833, Sir John Herschel was awarded the Royal Medal of the Royal Society, for his paper "On the Investigation of the Orbits of Revolving Double Stars." The Duke of Sussex, President, gave the following graphic account of his labors :

"Sir John Herschel has devoted himself, as you well know, for many years at least, as much from filial piety as from inclination, to the examination of those remote regions of the universe into which his illustrious father first penetrated, and which he has transmitted to his son as a hereditary possession, with which the name of Herschel must be associated for all ages. He has subjected the whole sphere of the heavens within his observation, to a repeated and systematic scrutiny. He has determined the position and described the character of the most remarkable of the Nebulæ. He has observed and registered many thousand distances and angles of position of double stars, and has shown, from the comparison of his own with other observations, that many of them form systems, whose variations of position are subject to invariable laws. He has succeeded by a happy combination of graphical construction with numerical calculations, in determining the relative elements of the orbits which some of them describe round each other, and in forming tables of their motions ; and he has thus demonstrated that the laws of gravitation, which are exhibited as it were, in miniature in our own planetary system, prevail also in the most distant regions of space ; a memorable conclusion justly entitled by the generality of its character to be considered as forming an epoch in the history of Astronomy, and presenting one of the most magnificent examples of the simplicity and universality of those fundamental laws of nature, by which their great Author has shown that he is the same to-day and for ever, here and everywhere.

"That he was not a mere meditative Philosopher, but one of laborious research and of a practical turn, appears from the imposing catalogue of his written works, a few of which I may be pardoned for enumerating: 12

papers on Optics; 28 on Astronomy; 10, Pure Mathematics, on Geology; on Photography; on Chemistry; on Natural Philosophy.

"The Encyclopedia Britannica boasts of excellent articles on Light and Sound, and Meteorology, now published separately."

A Manual of Scientific Enquiry, published by the Admiralty.

The Philosophical Transactions contain many of his valuable researches, especially those read before the Royal Society, 19 Nov., 1863, which will ever show his energy and perseverance in spite of the infirmities of his advancing age. In fact, turn where you may, light, emanating from Sir John, seems to cast its beams on almost every department of Science.

It may not be out of place to give an extract from his work "Outlines of Astronomy," a book which fills the student's mind with enraptured interest in the marvels which he reveals in plain and perspicuous language; for example:

"There is no Science which, more than Astronomy, draws more largely on that intellectual liberality which is ready to adopt whatever is demonstrated, or concede whatever is rendered highly probable, however new and uncommon the points of view may be, in which objects the most familiar may thereby become placed. Almost all the conclusions stand in open and striking contradiction with those of superficial and vulgar observation, and with what appears to every one until he has understood and weighed the proofs to the contrary, the most positive evidence of his senses. Thus, the earth on which he stands, and which has served for ages as the unshaken foundation of the firmest structures, either of art or nature, is divested by the Astronomer, of its attribute of fixity; and conceived by him as turning swiftly on its centre, and at the same time moving onwards through space with great rapidity. The sun and the moon, which appear, to untaught eyes, round bodies of no very considerable size, become enlarged on his imagination into vast globes: the one approaching in magnitude to the earth itself; the other immensely surpassing it. The planets which appear only as stars, somewhat brighter than the rest, are to him spacious, elaborate and habitable worlds; several of them much greater and far more curiously furnished than the earth he inhabits, as there are also others less so; and the stars themselves, properly so-called, which to ordinary apprehension present only lucid sparks or brilliant atoms, are to him suns of various and transcendent glory, effulgent centres of life and light to myriads of unseen worlds. So that, when after dilating his thoughts to comprehend the grandeur of those ideas his calculations have called up, and exhausting his imagination and the powers of his language to devise similes and metaphors illustrative of the immensity of the scale on which his universe is constructed, he shrinks back to his native sphere; he finds it, in comparison, a mere point; so lost, even in the minute system to which it belongs, as to be invisible and unsuspected from some of its principal and remote members."

Without fatiguing the Society, I think the following paragraph on the study of Natural Philosophy, will be its own apology for insertion.

"Among the most remarkable of the celestial objects, are the revolving double stars, or stars which to the naked eye or to the inferior telescope appear single, but if examined with high magnifying powers are found to consist of two individuals placed almost close together, and which when carefully watched are (many of them) found to revolve in regular elliptic orbits about each other; and, so far as we have as yet been able to ascertain, to obey the same laws which regulate the planetary movements. There is nothing calculated to give a greater idea of the scale on which the siderial heavens are constructed than these beautiful systems. When we see such magnificent bodies united in pairs, undoubtedly by the same bond of mutual gravitation which holds together our own system, and sweeping over their enormous orbits in periods comprehending many centuries, we admit at once that they must be accomplishing ends in creation which will remain for ever unknown to man; and that we have here attained a point in Science where the human intellect is compelled to acknowledge its weakness, and to feel that no conception the wildest imagination can form, will bear the least comparison with the intrinsic greatness of the subject."

England was not the only spot from which he made his observations. He found it desirable to carry on his investigations at the Cape of Good Hope, and for this far off scene of inquiry he embarked with his family at Portsmouth, 13 Nov., 1833. The course he prescribed to himself seems to have been to restrict his labors almost, if not entirely, to Stellar Astronomy. Still he did not omit to make many careful observations of the Nebulæ of Orion, of the Milky Way and of other heavenly phenomena; making accurate drawings, which he subsequently published.

In May, 1837, an extraordinary spot appeared on the sun's disc, the marvel of which was much increased when Sir John published his calculation that the crater of this supposed volcano was sufficiently large to allow the globe of the earth to pass in leaving all around a margin of 1000 miles.

On his return to England, in 1838, after, as he states, enjoying much happiness, together with the pleasures of good society, his grateful country bestowed upon him the dignity of a Baronetcy.

At this time, Photography beginning to attract much public attention, Sir John turned his thoughts to this beautiful art, directing his inquiries chiefly to that point so important to Photographers, the chemical action of solar rays.

Of the value attached to Sir John's scientific attainments we have abundant evidence in the instances in which he was called upon to occupy the place of advisor and councilor. As member of the Board of Visitors of the "Royal Observatory," when he was appointed to receive the annual report of its working and efficiency, a member of the "Standard Commission" on the question of the introduction of the "Metric System of Weights and Measures;" for many years as one of the leading members of the Council of the Royal Society.

On the retirement of Davies Gilbert, this venerable Society of savans

nearly succeeded in compromising its title, by almost electing the plebeian philosopher to the dignity of President, in preference to the Royal patron of science and literature, the Duke of Sussex. So keen was the contest that the subject of our memoir lost it only by 8 votes in a meeting of 240 members. He was President of the Astronomical Society three times. In 1845, he presided at the British Association for the Advancement of Science at Cambridge. Many learned European societies, beside those of his own country, rejoiced to inscribe his name on their rolls; but to none of them will our American Philosophical Society yield in its admiration, of this great citizen of the Republic of Literature and Science, as evinced by the bestowal upon him of their diploma of membership. In 1842, he was elected Lord Rector of Marischal College, Aberdeen.

The last of his public official positions, previously to his retirement into the quietude of a country life at Collingwood, in Kent, was that of Master of the Mint, to which he was appointed December 16, 1850, and which he retained until Professor Graham's appointment, April 27, 1855. In this office Sir John was a worthy successor of the great Sir Isaac Newton, who filled that office in the reign of William III.

In subsequent times, the Mastership acquired a political character and was conferred generally on members of the Cabinet, which continued until what is known familiarly amongst Mint employés, the Revolution of '51, by which the old system of charters, indentures and contracts for the meltings and coinages, being considered antiquated, it was desired by the higher powers to abolish. Naturally, this move caused much alarm and dissatisfaction; the distastefulness of which was, however, greatly modified by the gentle and considerate manner in which Sir John exercised the authority entrusted to him.

The labor and anxiety inseparable from a reconstruction of so important an establishment, much impaired the health of the subject of this memoir. Still his mental vigor did not succumb to bodily infirmity, as daily he was at his post about 11 o'clock, rarely leaving till 5 or 6 p.m., when he might be seen walking out with his portfolio under his arm, filled with papers to consider and revise, as an evening amusement.

Among the many alterations made by Sir John, he framed and calculated tables for standarding the various qualities of gold and silver, which superseded those said to have been Sir Isaac Newton's.

He sanctioned the abandonment of "Trial Plates" (designated by Sir John "Fiducial Pieces") which had been prepared from time to time and used for centuries, and presumed to be mathematically of the due proportions of the pure noble metal, but not really so. In lieu of this practice Sir John directed the Queen's Assay Master to use his best endeavors to obviate the evil, so that no officer of a foreign mint should be able to question the conventional purity of our British coin as being other than for gold 916.6, and for silver 925.

In giving effect to the Master's wishes, the Queen's Assay Master worked out the important correction by preparing and introducing chem-

ically pure gold and silver, in place of the standard trial plates. The following extract from Sir John's correspondence may be appropriately introduced here.

"The almost mathematical coincidence of the result of the Pyx (about 30 millions) with the legal standard, is the best proof which can be adduced of the admirable system of working the assays."

As illustrative of the unfailing kindness of this great man towards friends, as well as towards those, who had had the happiness to serve under him, the writer may be pardoned for introducing some of his *last* utterances contained in a letter, penned only five weeks before his departure to those realms of Light and Truth, amidst the wonders of which, while in the flesh, he *loved* to live.

"I am suffering under an attack of Bronchitis, which has lasted me all the winter, so excessively severe that I can hardly hold the pen, which must excuse the brevity of this, and being now in my 80th year, I can hope for no relief. I shall retain, however, *to the last*, a pleasing recollection of aid and support I received from you during the period of my administration of the Mint, and I know you will believe me ever, my dear sir, yours, most truly,

To H. W. F. (Signed) J. F. W. HERSCHEL.

In his domestic circle, he could unbend to the capacity of the young, in whose amusements he joined with spirit, and considering his advanced years, with wonderful energy. It may be instanced that, only a few years back, the great astronomer condescended to enter cordially into the children's Christmas gambols, and played in the most animated manner the part of Sir George with the Dragon; habiting himself in a coat of mail, extemporized from various culinary articles. His impromptu dialogue with his son as "the Dragon," was said by the elders to be absurdly clever. "The Herschels do everything well" was a common way of speaking of the philosopher and his family; so here the Dragon was so life-like, though made only of brown paper with a scarlet cloth tongue, and the knight looked so doughty, that the tableau nearly sent one of the children into convulsions.

Sir John F. W. Herschel, Bart., K. H., D. C. L., &c., was born at Slough, near Windsor, 7 March, 1792. He married, in 1829, Margaret Brodie, daughter to the Rev. Dr. Alexander Stewart, by whom he had a family of three sons and nine daughters. One is married to General, the Hon. Alexander Gordon, uncle of the present Lord Aberdeen, and now heir presumptive to that title. His youngest son is an officer in the Royal Bengal Engineers. He is succeeded in the title by his son Mr. William James Herschel, of the Bengal Civil Service, who was born in 1833 and married in 1864, Anne Emma Haldane Hardcastle, daughter of the late Mr. Alfred Hardcastle, of Hatcham, Surrey.

Sir John died at his seat, Collingwood, Hawkhurst, Kent, on Thursday, the 11th May, 1871, at 10 o'clock A. M., being in his 80th year. He was buried in Westminster Abbey, on Tuesday, the 19th May. His re-

mains were followed by the Presidents and many members of the various learned societies of England, also by the chief men of science in London.

The well-known Dean Stanley officiated on the mournful occasion, and on the following Sunday delivered in the Abbey one of his beautiful characteristic sermons, which may be found *in extenso*, in the July number of "Good Words," p. 453 (a work to which he occasionally contributed some popular papers on the wonders of the Universe). The Dean took his text from the 14th and 15th verses of the 1st chapter of Genesis.

"And God said let there be lights in the firmament of the Heaven to divide the day from the night; and let them be for signs and for seasons and for days and years; and let them be for lights in the firmament of the heaven to give light upon the earth; and it was so."

Glancing at the private sentiments of Sir John, in these days, when there appears to be an increasing antagonism between science and revelation, it is refreshing to remember how frequently in his writings, and in conversation with some of his friends, strong indications are observable, that the lofty mind of him who was a master in the science of the starry heavens could penetrate into higher regions still, and forget the proud achievements of intellect and science, in the humility of the adoring Christian; a humility which also manifested itself towards man in countless acts of generous sympathy and consideration. Of him truly it may be said in the language of a poetical tribute to his memory, which has recently appeared in a periodical of the day ("Good Words").

> "Science and learning led *his* mind, in reverent awe above;
> To him the voices of the stars proclaim'd their Maker's love."

In the above sketch of the scientific, official and personal character of the departed, it will be sufficiently apparent that with numberless other associations of the learned and scientific, in the decease of Sir John Herschel, our Society has to deplore the loss of a member whose name adorned the catalogue.

Mr. Dubois offered the following paper upon a *quasi* Coin, of Copper, affirmed to have been found at a great depth, in Illinois.

The annual reports of the Treasurer and Publication Committee were read and referred.

Pending nominations 679 to 682, and new nomination 683 were read; and the meeting was adjourned.

On a quasi Coin reported found in a boring in Illinois.

Read before the American Philosophical Society, Dec. 1, 1871,

By Wm. E. Dubois.

In July last, a letter was received at the Smithsonian Institute, from Mr. Jacob W. Moffit, of Chillicothe, Peoria county, Illinois, enclosing the photograph of a medal or coin, with the following particulars in relation to it:

"In August 1870, I took a contract of sinking a tubular well for Mr. Peter Cline, in this county. I had two men employed to assist in the labor, who are cognizant of all the facts connected with the finding of the coin.

"The following are the several strata through which we passed. We used a common ground auger, three inch bore:

"Soil, 3 feet. Yellow clay, 10; blue clay, 44; clay, sand, and gravel 4; purple clay, 19; brown "hard pan," 10; green clay, 8½; vegetable mould, 2; yellow clay, 2½; yellow hard pan, 2; mixed clay, 20½.

"Here we brought up *the coin*, on the auger, from a depth of one hundred and twenty-five feet.

"It has been examined by gentlemen in Chicago and St. Louis, without any result in explaining the mystery of its origin or date. It is my desire that a further investigation be made. I can, if necessary, send affidavits of myself and other parties as to the truth of these statements."

[Signed] Jacob W. Moffit.

It may here be added, that the place is in a great prairie, near the centre of the State, and near the Illinois river; about 80 miles east of the Mississippi river.

Professor Henry having repeatedly referred rare coins to me, took the same course on this occasion, giving leave to communicate the facts to this society, if it was thought proper.

An examination of the piece itself was necessary; and in reply to my request the owner forwarded the same, with further details, to wit:

"In answer to your questions I must say, that very few wells or shafts in this region have attained a depth of more than 50 or 75 feet, except in the valleys, where occasionally we find a well, through sand and gravel drift, at the depth of 100 feet.

"The only token of civilization discovered at a similar depth, in this State, was taken from a shaft in Whiteside county, about 20 years ago. The workmen at the depth of 120 feet discovered a large copper ring or ferrule, similar to those used on ship spars at the present time. They also found something fashioned like a boat-hook.

"There are numerous instances of relics found at lesser depths. A spear-shaped hatchet, made of iron, was found imbedded in clay at 40 feet; and stone pipes and pottery have been unearthed at depth varying from 10 to 50 feet in many localities.

"No rational estimate has ever been made of the rate of annual earthy deposit. Our prairie land seems to have been built up by a deposit from

waters whose current set in from the N. W., changing its course only when in contact with some (then) eminence now far below the surface. The soil is seldom over three feet in thickness, usually underlaid by a yellow hard-pan of two to three feet. Wood is quite common at all depths at which wells have been sunk in blue clay.

"Nothing has been found in any of the Western mounds (as far as I am informed) bearing any resemblance in form or character to this coin.

"On taking the coin from the auger, I washed the clay from it with water. It then presented no appearance of corrosion, bearing a dull red hue, such as is common to old copper. However, after a few minutes, exposure to the air, it began to blacken, and in a short time was encrusted with a dark green, gummy coat, which I allowed to harden, and then removed by friction."

Thus far from Mr. Moffit. I learn from another source, that Chillicothe is built upon an alluvium of the Illinois river, very sandy, loose, and easily washed away. The river thereabouts is widened into a lake, about one mile and a quarter wide, and twelve miles long. The French pioneers went through that region, about the close of the seventeenth century. Whether the ground on which Chillicothe stands, has been made by the river, to the depth of 125 feet, since the entrance of the whites, is a point on which the residents there, with or without geological instruction, cannot venture an opinion.

As to the facts as above stated, there is every reason to rely upon their accuracy. I have to add some remarks on the physical and artistical traits of the coin itself.

Properly speaking, it is not a *coin* or medal, since the marks upon it have not been produced by striking, but by engraving or etching; and they are sunken, or intaglio. It is of copper in good condition, in shape polygonal approaching to circular, about one and an eighth inch in diameter; somewhat pitted by corrosions, and with very rude figures and inscriptions on both sides. The central image on one side is that of a man, or a child; on the other are two animals, one of them like a wild cat, with conspicuous ears. The legends are plain enough, to any one who can read them; but being somewhere between Arabic and Phonographic, without being either, they are sufficiently puzzling. Happily we have members whose knowledge of paleography may throw some light. For myself, I have seen nothing like it.

As to the other artistic characters, the metal proves, by a delicate gauge, to be very uniform in thickness; more so than could be attained by the beating out of a hammer in savage hands. I therefore feel sure it has passed through a rolling-mill; and if the ancient Indians had such a contrivance, it must have been pre-historic.

There are other tokens of the machine shop. Any one can see that the piece has been shaped, not with much symmetry, with shears or chisel; and the sharp edge taken down with a file. Coins or medals were not thus finished in ancient times, but they were in the middle ages, and in

Spanish America down to about 150 years past. (Tapping the edge with a hammer, was also in use).

If the figures and characters were made with a tool, it must have been a very rude one, since a "flat-nosed" graver would have left a smooth trough, while here it is rough and granular. This would suggest the greater likelihood of *etching*, were it not inconceivable that so advanced an art should have been practiced long ago on the Western prairies. The mineral acids, used for such work, were nowhere known until about the fourteenth century; and in Illinois, while we might suppose *agua ardiente*, we cannot concede *aqua fortis*, longer ago than one century. On the whole, it has been worked out with a very crude instrument.

As to the condition of the piece, and the discolorations; it is well known that copper, exposed to the air, acquires a superficial sub-oxide or dioxide, which protects it from further destruction. Very many ancient copper coins have been turned up by the spade or plough, which with a little cleaning up, look as if just out of the mint. I herewith show a specimen of Tetricus, a Roman usurper of the purple, in France, about A. D. 270; entirely free from corrosion. I also show a more interesting piece, which with many others, was ploughed up in the southern part of England, about 30 years ago. They were all so encrusted as to be illegible, and the owner gave me a choice at haphazard. On removing the coat of mail, and leaving only the mixture of brown and black oxides, it turned out to be a coin of Carausius, who established himself as a Roman Emperor in Britain, A. D., 287; as long before William the Conqueror, as William was before Victoria. This piece is rare and in perfect order, and forms a part of the Mint collection.

Some ancient coins, especially those with a slight alloy of tin or calamine, making them bronze or brass, are beautifully coated and protected with the green carbonate, the same as that which formed on the Illinois piece before cleaning. I herewith show one of these patinated pieces, a coin of Augustus, also from the Mint Cabinet. They may have been in favorable hiding-places, such as cinerary urns, or columbaria.

All things considered, I cannot regard this Illinois piece as *ancient*, nor *old*, (observing the usual distinction); nor yet *recent;* because the "tooth of time" is plainly visible.

What the piece was made for, is a part of the inquiry. Not for current money, because it would take a long time to make a handful; more likely a work of amusement, possibly to exercise the antiquarians. But how it got into such a deep place, supposing it a *bona fide* discovery which I cannot call in question, is a very perplexing point, and I gladly hand over the explanation to any one willing to undertake it. Certainly it seems, in connection with the finding of the copper ring, and other articles of iron and wood, at considerable depths, to form an item in the study of the formation of the superficial strata in that interesting section of our country.

Since the foregoing was written, I am favored with the suggestions (in writing) of Professor Lesley. He suspects that if anything, it is an astrological amulet. There are upon it the signs of Pisces and Leo. The

figures, on the obverse and reverse faces correspond in the attitude of the left arm raised and flourishing a whip, or thunderbolt. He reads the date 1572, and says that no geologist can accept the statement that a piece of that age could be lying naturally at a depth of 125 feet, under an Illinois prairie. The piece was placed there as a practical joke, though not by the present owner; and is a modern fabrication; perhaps of the sixteenth century; possibly of Hispano-American, or French-American origin. It may have some connection with the journeys of the early French priests or their voyageurs.

I would only add, that those views are forcible, but yet they take imposture for granted, and in so doing, leave us in this dilemma; that a curious piece was made many years ago, and held for the purpose of trick, until a deep hole should be made, long afterwards, in which to bury it, and complete the deception. It is also very hard to believe, that an intelligent and experienced operator in this line would allow himself to be sported with by workmen, and take so much pains, far and near, to ascertain what kind of article he had found.

Mr. Lesley explained:

He considered the integrity, experience and vigilance of the well sinker no guarantee against the surreptitious insertion of the coin. It is impossible to prevent a practical joke of that sort when the jester is resolved to have it so. Experience furnishes a thousand proofs of this in our extensive oil regions, where all kinds of rubbish have been brought to the surface from considerable depths; nails, anthracite coal, California nuggets, "butter of antimony," Lake Superior Red hematite iron ore, &c.

It looks as if there is a good deal of this sort of thing going on in the west. The copper-ring and boat-hook "taken from a shaft at Whitside; at a depth of 120 feet," "the *iron* spear-shaped hatchet embedded in clay at 40 feet" mentioned in the paper, are subjects for the same incredulity. The only possible explanation, excluding an imputation of fraud, in the latter case, would presuppose the recent filling up of a hole in the river bed with clay, through which a piece of iron might slowly settle down.

The discovery of a circular stone fire-place, with embers, by Mr. Latrobe's party of engineers in a gravel cut for the road bed of the Baltimore and Ohio R. R., many years ago, at a depth of 50 or 60 feet beneath the surface, is a circumstance belonging to quite a different category.

In the present case we have an evident imitation of Mediterranean coins. But the central figures are unmistakably Red Indian in their character. It is either unique of its kind, or one of a very small class. The probabilities against a borehole striking such an object are simply infinity to one. The improbabilities of the coin being at or near the surface, and being worked out from the wall of the hole by the friction of the rods, is equally great. There is too much method in the arrangement of the elements of the legend to doubt that the maker had a definite idea to express. A compound oval symbol occupies the right edge on each face, and may have a phallic significance. But the two human figures on one

face seem rather to be in conflict than in conjunction. The head dress may represent hair, or may represent the Indian warrior's feather crest.

Professor Trego remarked that he had seen the once famous grave mound relic and the man "who discovered" and possessed it, and believed it to be fraudulent. He had no faith in such discoveries in the west.

Stated Meeting, December 15, 1871.

Present, twelve members.

Dr. Wood, President, in the chair.

Letters of acknowledgment were received from the Anthropological Institute of G. B. and Ireland, Nov. 24, 1871, (83, 84, 85, 86, and Trans., Part 1, 1870). The N. V. d. P. R. u. W. at Bonn, Feb. 5. 1871 (82, 83). The N. Ges. Emden., Sept. 21, 1871 (84, 85); and the Linnean Society at Bordeaux, July 12, 1870 (78, 79).

Letters of envoy were received from the Societies at Bordeaux and Emden, Sept. 22, 1871; the Geographical Society at Vienna, Sept. 3, 1871; the American Legation at the Hague, Nov. 28, 1871; and the U. S. Naval Observatory, Dec. 5, 1871.

The death of Count Agenor Etienne de Gasparin, in June last, was announced by the Secretary.

Professor Cope communicated his views on the Method of Creation of Organic Forms, with illustrations on the blackboard.

Professor Cope added a Catalogue of Pythonomorpha found in the Cretaceous strata of Kansas.

Pending nominations 679 to 683, and new nominations 684 to 688 were read.

On motion of Mr. Price, the following resolution was adopted:

Resolved, That the Treasurer be authorized to pay to the Treasurer of the Fairmount Park Commissioners, three hundred dollars ($300) of the interest or rent lately received on the Michaux Legacy, to be applied towards the Michaux Grove and Michaux Nursery of Oaks in the Park, agreeably to the resolution of March 18th, 1870 (see page 312, Vol. XI., Proceedings A. P. S.)

And the meeting was then adjourned.

THE METHOD OF CREATION OF ORGANIC FORMS.

By Ed. D. Cope.

(*Read before the American Philosophical Society, December 15th,* 1871.)

Chapter I.—On the Law of Acceleration and Retardation. Nature of law of Natural selection. Two kinds of evidence. Illustration. Examples from cervidæ, helicidæ, insects and men.

Chapter II.—The Law of Repetitive Addition. Segment and cell repetition. Illustration from limbs and vertebral column. A, On segment addition; definitions. On repetition in bilateral and anteroposterior symmetry; in structure of compound teeth; in segments of articulata; limbs of Reptilia; brain of lamprey. B, On cell repetition; simple segment a repetition of cells; simple diverticulum the same. The cell theory; the nucleated cell. C, Synthesis of repetition. From unicellular to multicellular animals; simple repetition to compound repetition; *Actinia, Lepidosiren, Ichthyosaurus, Plesiosaurus, Tænia;* the heart; mammalian teeth. D, On growth force; relation to other forces; definition. E, Direction of repetition, its location, centrifugal and longitudinal; movements longitudinal. Inheritance; its relation to growth force.

Chapter III.—The Law of Use and Effort. Points to be investigated. A, On the location of growth force. Relation of effort to use. Rudimental characters. Examples of growth under influence of physical laws; Examples of colors under influence of light. Use and disuse of gills. Rattlesnake; horned animals. Teeth of ruminants. B, Change in amount of growth force. Local increase of growth force. Convoluted structures; brain, teeth, cotyledons. Absolute loss of growth force. Teeth and toes of Ruminants; incisors of Rodents.

Chapter IV.—On Grade Influence. A, On the nature of Grade influence or Bathmism. Definitions. In plants; in animals. Increase in time of Bathmism and growth force. Vital forces and vital influences. Thought force. Origin of Bathmism in time. B, Physiological origin of Bathmism. Function of nervous system in force conversion. Automatic and habitual movements. Effect on nervous system. C, The transmission of grade influence. Secretion in general. Spermatozoöids.

Chapter V.—Intelligent Selection. Development of intelligence. Stimuli to use. Compulsion, Choice; Bees, Food, Rattlesnake; Change of color; Mimetic analogy, Examples. Development of character.

In the present state of biological science, essays like the present can only be tentative in so far as they treat of the laws of evolution. Nevertheless the present time is preëminently one of generalization in this field, and properly so. Facts have been accumulating for a long period, and are now sufficiently numerous to yield important results, under proper classification and induction. Darwin led the way in this work, and the development hypothesis is regarded as demonstrated by most biologists. The discussion of the laws of its progress involves a multitude of subordinate hypotheses. In the following essay, these are arranged under five prominent heads, viz: 1, The law of Acceleration and Retardation; 2. The law of Repetitive Addition; 3. The law of Use and Effort; 4. The law of Grade Influence; 5. The law of Intelligent Selection. Of these, the first and second are regarded by the author as demonstrated, the third and fourth as only reduced to a partial demonstration, while the fifth is a consequence of the third, and stands or falls with it.

The discussion of this subject divides itself into two parts, viz: a consideration of the proof that evolution of organic types or descent with modification has taken place; and secondly, the investigation of the laws in accordance with which this development has progressed. As the latter involves the use of the evidence included in the former, I will not devote a special chapter to the proof for evolution.

The influences and forces which have operated to produce the type structures of the animal kingdom have been plainly of two kinds; 1. *Originative*, 2. *Directive*. The prime importance of the former is obvious; that the latter is only secondary in the order of time or succession, is evident from the fact that it controls the preservation or destruction of the results or creations of the first, and thus furnishes the bases of the exhibitions of the originative forces in the production of the successive generations of living beings.

Wallace and Darwin have propounded as the cause of modification in descent their law of natural selection. This law has been epitomized by Spencer as the "survival of the fittest." This neat expression no doubt covers the case, but it leaves the origin of the fittest entirely untouched. Darwin assumes a "tendency to variation" in nature, and it is plainly necessary to do this, in order that materials for the exercise of a selection should exist. Darwin and Wallace's law is, then, only restrictive, directive, conservative, or destructive of something already created. I propose then to seek for the originative laws by which these subjects are furnished—in other words, for the causes of the origin of the fittest.

It has seemed to the author so clear from the first as to require no demonstration, that Natural Selection includes no *actively* progressive principle whatever; that it must first wait for the development of variation, and then after securing the survival of the best, wait again for the best to project its own variations for selection. In the question as to whether the latter are any better or worse than the characters of the parent, natural selection in no wise concerns itself.

I. ON THE LAW OF ACCELERATION AND RETARDATION.

There are two modes of demonstration of evolution, both depending on direct observation. One of these has been successfully presented by Darwin. He has observed the origin of varieties in animals and plants, either in the domesticated or wild states, and has shown, what had been known to many, the lack of distinction in the grades of difference which separate varieties and species. But he has also pointed out that species (such, so far, as distinctness goes) have been derived from other species among domesticated animals, and he infers by induction that other species, whose origin has not been observed, have also descended from common parents. So far, I believe his induction to be justified; but when from this basis evolution of divisions defined by important structural characters, as genera, orders, classes, etc., is inferred, I believe that we do not know enough of the uniformity of nature's processes in the premises to enable us to regard this kind of proof as conclusive.

I therefore appeal to another mode of proving it, and one which covers the case of all the more really structural features of animals and plants.

It is well known that in both kingdoms, in a general way, the young stages of the more perfect types are represented or imitated with more or less exactitude by the adults of inferior ones. But a true identity of these adults with the various stages of the higher has, comparatively, rarely been observed. Let such a case be supposed.

In *A** we have four species whose growth attains a given point, a certain number of stages having been passed prior to its termination or maturity. In *B* we have another series of four (the number a matter of no importance), which, during the period of growth, cannot be distinguished by any common, *i. e.*, generic character, from the individuals of group *A*, but whose growth has only attained to a point short of that reached by those of group *A* at maturity. Here we have a parallelism, but no true evidence of descent. But if we now find a set of individuals belonging to one species, or still better, the individuals of a single brood, and therefore held to have had a common origin or parentage, which present differences among themselves of the character in question, we have gained a point. We know in this case that the individuals, *a*, have attained to the completeness of character presented by group *A*, while others, *b*, of the same parentage have only attained to the structure of those of group *B*. It is perfectly obvious that the individuals of the first part of the family have grown further, and, therefore, in one sense faster, than those of group *b*. If the parents were like the individuals of the more completely grown, then the offspring which did not attain that completeness may be said to have been *retarded* in their development. If, on the other hand, the parents were like those less fully grown, then the offspring which have added something, have been *accelerated* in their development.

I claim that a consideration of the uniformity of nature's processes, or inductive reasoning, requires me (however it may affect the minds of others) to believe that the groups of species, whose individuals I have

*A cut explaining this proportion will be found at the end of the essay.

never found to vary, but which differ in the same point as those in which I have observed the above variations, are also derived from common parents, and the more advanced have been *accelerated* or the less advanced *retarded*, as the case may have been with regard to the parents.

This is not an imaginary case, but a true representation of many which have come under observation. The developmental resemblances mentioned are universal in the animal, and probably in the vegetable kingdoms, approaching the exactitude above depicted in proportion to the near structural similarity of the species considered.

Example 1. It is well known that the *Cervidæ* of the Old World develop a basal snag of the antler, (see Cuvier, Ossemens Fossiles, and Gray, Cat. British Museum,) at the third year; a majority of those of the New World (genera Subulo, Cariacus) never develop it except in abnormal cases in the most vigorous maturity of the most northern Cariacus (*C. virginianus*), while the South American Subulo retains to adult age the simple horn or spike of the second year of all *Cervidæ*.

Among the higher *Cervidæ*, Rusa and Axis never assume characters beyond an equivalent of the fourth year of Cervus. In Dama the characters are, on the other hand, assumed more rapidly than in Cervus, its third year corresponding to the fourth of the latter, and the development in after years of a broad plate of bone, with points being substituted for the addition of the corresponding snags, thus commencing another series which terminates in the great fossil elk, Megacerus.

Returning to the American deer we have Blastocerus, whose antlers are identical with the fourth year of Cariacus. Corresponding with the Dama-Megacerus type of the Old World we have the moose (Alces) developing the same palmate horn on the basis of Cariacus (*i. e.*, without eye-snag.)

Example 2.—I select the following series, embracing the majority of the genera of the North American Helicidæ.*

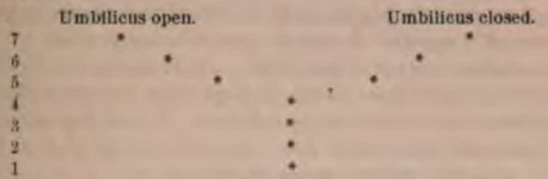
1. Turns of spire very few; wide umbilicus; shell thin, with thin lips.......... *Binneya*.
2. Turns few, but more; rest as above.......... *Vitrina*.
3. Turns still more numerous; rest as above.......... *Hyalina*.
4. As No. 3, but lip thickened inside.......... *Hygromia*.
5. Coiled; *umbilicus closed;* lip thickened inside and out, *Tachea* and *Pomatia*.
6. Same, with a parietal tooth.......... *Mesodon*.
7. Same, with parietal and two interior lip teeth.......... *Isognomostoma*.

* * Recommencing at No. 4. All with *open umbilicus*.

5. As No. 4, but lip thickened in and out.......... *Arionta*.
6. Same as No. 5, but with parietal tooth.......... *Polymita*.
7. Same, with both parietal and lip teeth.......... *Triodopsis*.

* See Tryon, Terrestrial Mollusca of the United States. Probably other (*e. g.* dental) characters distinguish some of these genera, but the above furnishes the history of one set of characters.

The successional relation of these genera may be represented in such a diagram as this :



In the history of the growth of the genera Isognomostoma and Triodopsis, the extreme forms of the two series, it is well known that at first the coils of the shell are extremely few, as in Binneya ; and that like it, it is very thin and with a delicately thin edge ; that the turns increase successively in number, as in Vitrina and Hyalina, and that finally the lip thickens as in Hygromia. Then the umbilicus may close as in Tachea, or (in Triodopsis) remain open as in Arionta. In either case a tooth is soon added on the body whorl (Polymita, Mesodon), and finally, the full maturity of the shell is seen in the added teeth of the inside of the lip margin. How many of the stages of the genera *Triodopsis* and *Mesodon* are identical with the genera of the series which represent them, I leave to more thorough conchologists, but that some now exhibit and all have once presented illustrations of the relation of exact parallelism, I cannot doubt.

Example 1.—An abundant race of the American deer, *Cariacus virginianus*, exists in the Adirondack region of New York, in which the development of the antlers never progresses beyond the spike stage of the second year. Therefore, some individuals of this species belong to Cariacus and some to Subulo.

Example 2.—A large part of the individuals of the common snail, *Mesodon albolabris*, never develop the tooth of the body-whorl, characteristic of the genus whose definition has to be modified to retain them.

Example 3.—Many individuals of *Triodopsis tridentata* from eastern North Carolina occur without the lip-teeth, characteristic of the genus *Triodopsis*. Hence these specimens, though of common origin with others of the species, must be referred to another genus.

Example 4.—Structural characters are known in many, if not all, species which are said to be "inconstant," being present or absent indifferently, thus being useless for definition. They may be rudimental when present or considerably developed. The presence or absence of wings in some species of insects may be cited; also the presence of generic characters in the male sex of many Coleoptera and their absence in the females. The characters of males, females, workers and soldiers in bees and ants may be added. All these facts belong to the same category as those cited among deer and mollusks and have a similar explanation.

Example 5.—It does not seem to be the law in "retardation" that parallelisms exhibited by the series in its rise to its highest point of development should retrace the steps by which it attained it, and that "exact

parallelisms" should be exhibited in a reversed order. Parallelisms, it is true, are exhibited; but so far as I have observed always "inexact," often in a high degree. A marked case of retardation occurs in the dental development of a number of persons who have come under my observation in the neighborhood of Philadelphia. It is not very uncommon to find persons in whom the third molars in both jaws are incomplete as to number, one, two, three, or all, being deficient. It is still more common for them to be incompletely covered by the enamel layer, and to become in consequence so worthless as to require early removal. I am acquainted with two families in which the absence of the exterior upper incisor on each side is common. In one of these the second and third generation have inherited it from the mother's side, and it now characterizes many of the children. The significance of this modification will be best understood by examining the dental structures of the *Quadrumana* in general. Commencing with the highest family and its abnormal dentition, we have:—

	Incisors.	Canines.	Premolars.	Molars.
Hominidæ, Abnormal.	$\frac{1}{2}$	$\frac{1}{1}$	$\frac{2}{2}$	$\frac{3}{3}-\frac{2}{2}$
Hominidæ, Normal.	$\frac{2}{2}$	$\frac{1}{1}$	$\frac{2}{2}$	$\frac{3}{3}$
Simiidæ	$\frac{2}{2}$	$\frac{1}{1}$	$\frac{2}{2}$	$\frac{3}{3}$
Cebidæ	$\frac{2}{2}$	$\frac{1}{1}$	$\frac{3}{3}$	$\frac{3}{3}$
Lemuridæ	$\frac{2}{3}$	$\frac{1}{1}$	$\frac{3}{3}-\frac{2}{2}$	$\frac{3}{3}$
Mammalia, Normal	$\frac{3}{3}$	$\frac{1}{1}$	$\frac{4}{4}$	$\frac{3}{3}$

In this table we see a decline in the number of teeth of the higher groups. Thus, the premolars are one less than the normal number in the whole order, and they lose one in each jaw in the Old World apes, and man. The molars maintain the normal number throughout, but the third in both jaws is in the *Simiidæ* reduced by the loss of a fifth or odd tubercle, thus becoming four-lobed. In the upper jaw, this is first lost in the Semnopithecus; in the lower, in the next highest genus Cercopithecus. In Homo its appearance is "retarded," the interval between that event and the protrusion of the second molar—six to ten years—being relatively greater than in any genus of *Quadrumana*. Its absence is then the result of continued retardation, not of a new and adaptive suppression, and is of direct systematic zoological value.

In the incisors a reduction is also plainly visible, as we pass from the most completely furnished mammals to the genus Homo. One from the upper jaw is first lost, then in the *Cebidæ*, one from the lower also. The number remains the same through the *Simiidæ* and normal *Hominidæ*, but in the abnormal cases cited, the process of reduction is continued and another incisor from each side disappears. That this also is truly "retardation" is also evident from the fact, that the exterior incisor is the last developed, being delayed in ordinary growth a year later than those of the inner pair. The same retardation is seen in the quadrumane *Cheiromys* (the *Aye-aye*), and the whole order *Rodentia*. In the latter, the rare presence of the reduced second incisors, as in *Lepus*, shows a less de-

gree of this modification. This retardation is also of systematic importance, and, should either of the characters described be constant in any of the species of the genus *Homo*, would at once entitle it to new generic rank. The very frequent absence of the posterior molars (wisdom teeth) has been recently found to characterize a race in India. Should this peculiarity prove constant, this race would with propriety be referred to as a new genus of *Hominidæ*, as we have many cases of very similar species being referred to different genera. It is altogether probable that such will, at some future time be the condition of some race or races of men.*

I am now disposed to regard the above as the method of production, not only of generic but of all other, including specific characters. It would appear that by excessive acceleration or retardation, some of the characters of a series may be skipped, but observations are not conclusive on this point, since very close examination is necessary for the appreciation of very transitory embryonic conditions.

II. ON THE LAW OF REPETITIVE ADDITION.

The origin of new structures which distinguish one generation from those which have preceded it, I have stated to take place under the law of *acceleration*. As growth (creation) of parts usually ceases with maturity, it is entirely plain that the process of acceleration is limited to the period of infancy and youth in all animals. It is also plain that the question of growth is one of nutrition, or of the construction of organs and tissues out of protoplasm.

The construction of the animal types may be referred to two kinds of increase—the addition of identical segments and the addition of identical cells. The first is probably to be referred to the last, but the laws which give rise to it cannot now be explained. Certain it is that segmentation is not only produced by addition of identical parts, but also by subdivision of a homogeneous part. In reducing the vertebrate or most complex animal to its simplest expression, we find that all its specialized parts are but modifications of the segment, either simply or as sub-segments of compound but identical segments. Gegenbaur has pointed out that the most complex limb with hand or foot, is constructed, first, of a single longitudinal series of identical segments, from each of which a similar segment diverges, the whole forming parallel series, not only in the oblique transverse, but generally in the longitudinal sense. Thus, the limb of the Lepidosiren represents the simple type, that of the Ichthyosaurus a modification. In the latter, the first segment only (femur or humerus) is specialized, the other pieces being undistinguishable. In the Plesiosaurian paddle the separate parts are distinguished; the ulna and radius well marked, the carpal pieces hexagonal, the phalanges defined, etc.

As regards the whole skeleton the same position may be safely assumed. Though Huxley may reject Owen's theory of the vetebrate char-

*The preceding section is merely an abbreviation with new illustrations, of the propositions brought forward in the writers "Origin of Genera," 1868, where a considerable extension of the subject will be found.

than in the case of double bilateral symmetry, since the exceptions appear to be so universal. Nevertheless, I believe it to be as much a part of the law of Repetitive nutrition as the other. The antero-posterior homologies even of the human skeleton have been largely demonstrated, but as usual, we must appeal to the lower forms for a clear view of it. In the rudimental skeletal axis we find such symmetry almost perfect in the *Amphioxus*, but in no other vertebrate. In limbs we have it clearly indicated in the Reptilian order *Ichthyopterygia*, and in the Piscine order *Dipnoi*, where the anterior and posterior are scarcely or not all distinguishable. In the scapular and pelvic arches we find it also approximated in the first-named orders.

In the nervous system it also exists approximately in the *Amphioxus*. It is not seen in any vertebrate, and in but few other animals, in the digestive system, but it appears to exist in some lower articulata in both the respiratory and circulatory systems.

c. As illustrations of exact repetition involving large portions of the organism the higher Polyps may be cited, which differ from the lower chiefly by the addition of similar septa and similar tentacles. Examples of repetition of nearly the whole organism, may be found in many Entozoa as *Taenia*, where the cephalic segment only differs from the others, the remainder or proglottides being alike. The most entire repetition of structure is seen in *Vibrio*, where the segments are all alike, there being none representing a head.

d. As an example in special details of structure, the segments of the lowest brain (that of the lamprey) are repetitions of the first one. The pelvic arch of *Ichthyosaurus* when first created, was a repetition of the scapular, and the hind limb, of the fore limb. The segments of the limbs of the *Dipnoi* are mere repetitions, the later created of the earlier. The special parts of the pes and manus of *Ichthyosaurus* are simply repetitive efforts of growth-force joined with a diminishing amount. The addition of a digit often distinguishing one genus of Salamanders or Saurians from another, is evidence of a similar repetitive effort. The low mammal *Ornithorhynchus*, possesses but a single tooth in each jaw; the simple teeth of armadillos and cetaceans, increasing as they have done from a single commencement as in the monotreme cited, present examples of repetitive acceleration of growth force.

e. Complication of a single element of repetition is accomplished apparently by a double repetition. This is best understood by the consideration of the transition from simple to complex teeth. In the cetaceans this occurs in the Squalodonts; the cylindric incisors are followed by flattened ones, then by others grooved on the fang, and then by two-rooted, but never double-crowned teeth. This is the result of antero-posterior repetitive acceleration of the simple cylindric dental type of the ordinary toothed cetacean.

Another mode of dental complication is by lateral repetition. Thus, the heel of the sectorial tooth of a Carnivore is supported by a fang alongside of the usual posterior support of a premolar, and is the result of a repetitive effort of growth force in a transverse direction. More complex teeth, as the tubercular molars, merely exhibit an additional lateral repetition, and sometimes additional longitudinal ones. As is well known, the four tubercles of the human molar commence as similar separate knobs on the dental papilla.

The above are cited as examples to explain the meaning of the proposition. When fuller demonstration is desired a greater number might be given.

B. On Cell Repetition.

That each additional act of creation in growth was originally identical with one which preceded it, and therefore an *exact repetition* in its character and results, is proven by the following considerations.

It has been already determined by the study of homologies that all organs and parts of an organism can be referred to an original simple archetype.

The question then remains as to whether the first element or lowest term, of a given organized part is essentially a new structure, or whether it be a repetition of some previously existing one. It may be asserted that the simplest expressions which shall cover all organs, are the solid segments and the hollow sack and tube. For example, we have already noted that the ultimate element of the limb is the first segment of the single ray of Lepidosiren. Is this short cartilaginous cylinder (which probably represents the fore-limb of some undiscovered member of the Dipnoi), a result of the repetition of a pre-existent structural element? This is no doubt the case, for as will be shown beyond, cartilage, though the least cellular of all the tissues is formed originally by cell-repetition or division. Again, the ultimate lobules of the most complex gland are but repetitions of the diverticula of the simply branched, and each of the latter repetitions of the simple cul-de-sac, which has its origin in a convexity of an originally plane surface. This convexity is again the result of repetition of cells or cell-division, whereby their number is increased and the surface rendered convex.

We are thus in both the solid segment, and hollow sack, brought down to cell repetition. Thus it is with organs, as with entire animals, in which, following the line of simplification, we reach at last forms composed of cells only, (*Actinophrys*, *e. g.*) and then the unicellular, (*Amœba*).

If this be the origin of organs, the question whether repetitive growth has constructed tissues, remains for consideration.

In growth, each segment—and this term includes the parts of a complex whole or parts always undivided, (as the jaw of a whale or the sac-body of a mollusk)—is constructed, as is well known, by cell division. In the growing fœtus the first cell divides its nucleus and then its whole outline, and this process repeated millions of times produces, according to

the cell theory, all the tissues of the animal organism or their bases, from first to last. That the ultimate or histological elements of all organs are produced originally by repetitive growth of simple nucleated cells, with various modifications of exactitude of repetition in the more complex, is taught by the cell theory. The formation of some of the tissues is as follows:

First Change—Formation of simple nucleated cells from homogeneous protoplasm or the cytoblastema.

Second—Formation of new cells by division of nucleus and body of the old.

Third—Formation of tissues by multiplication of cells with or without addition of intercellular cytoblastema.

A. In connective tissue, by slight alteration of cells and addition of cytoblastema.

B. In blood, by addition of fluid cytoblastema (fibrin) to free cells (lymph corpuscles), which in higher animals (vertebrates) develop into blood-corpuscles by loss of membrane, and by cell development of nucleus.

C. In muscles, by simple confluence of cells end to end, and mingling of contents (Kölliker).

D. Of cartilage, by formation of cells in cytoblast which break up, their contents being added to cytoblast; this occuring several times, the result being an extensive cytoblast with few and small cells (Vogt). The process is here an attempt at development with only partial success, the result being a tissue of small vitality.

Even in repair-nutrition recourse is had to the nucleated cell. For Cohnheim first showed that if the cornea of a frog's eye be scarified, repair is immediately set on foot by the transportation thither of white or lymph or nucleated corpuscles from the neighboring lymph heart. This he ascertained by introducing aniline dye into the latter. Repeated experiments have shown that this is the history in great part of the construction of new tissue in the adult man.

Now, it is well known that the circulating fluid of the fœtus contains for a period only these nucleated cells as corpuscles, and that the lower vertebrates have a greater proportion of these corpuscles than the higher, whence probably the greater facility for repair or reconstruction of lost limbs or parts enjoyed by them. The invertebrates possess only nucleated blood corpuscles.

C. Synthesis of Repetition.

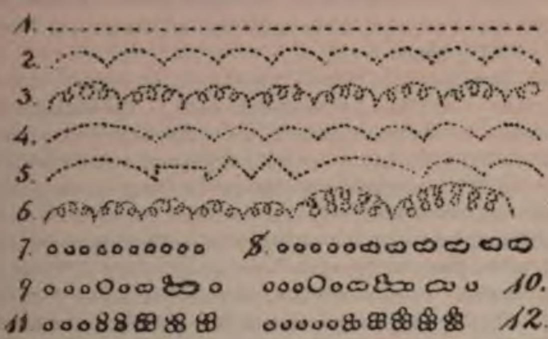
That growth force is capable of exhibiting great complexity of movement with increase in amount, will now be shown. That this quality of complication is one of its distinguishing features will appear plain.

The simplest forms of life, as stated by Hæckel, are simply homogeneous drops of protoplasm (*Protamoeba*). These only grow by ordinary accretion, and display a form of self division or reproduction which is the simplest possible; *i. e.*, the bisection of the mass by contraction at opposite points.

The next grade of animal type is represented by the nucleated cell. This is simple in *Amœba*, complex in *Actinophrys*, etc. With such forms as the latter, cell growth begins, and its development is accomplished by cell division. This is simple repetition of ultimate parts. In the growth of all higher types, we have nothing more than this, but following a law of *complex repetition*. Thus in the growth of the parts of an archetypal vertebral column, or an archetypal limb, we have the repetition of cell growth till the first segment is formed, when it ceases at that point, and repeats the process again, forming another segment like the first; repetition within repetition. So with the construction of muscular tissue; first, the nucleated cell repeated in a series, whose adjacent walls disappear, and whose cell contents flow together, thus forming a fibrilla; then a repetition of the same process forming a second fibrilla; and so on to the completion of thousands of them in fasciculi.

Let us then trace the series of repetitions and duplicated and still more complex repetitions, seen in following up animal forms from their archetypes.

In the simplest repetition of cell growth in a longitudinal direction we have *Vibrio;* in the centrifugal, *Actinophrys*. The former may be represented by a line of simple dots, thus :—Fig. 1.



In a complex repetition we rarely have the same degree of complication in each repeated part. We have it centrifugally almost perfect in a Cœlenterate (*Actinia*) and linearly in some of the lower Entozoa. An archetype of the latter kind might be represented thus :—Fig. 2. In a more complex form, as of the proglottides of *Tænia*, thus :—Fig. 3. The same might represent an archetypal vertebrate.

If now we attempt to express the complication of an organ by modified repetition of once identical parts, the history of extremities will serve us. Thus the limb of Lepidosiren which is composed of identical segments may be thus represented :—Fig. 2. Each longitudinal segment of the limb of Ichthyosaurus may be similarly represented with a modification, in size only, of the proximal or humerus; thus :—Fig. 4. But in *Plesio-*

saurus, an important series of changes of shape (but not in complexity) appears, which may be represented thus:—Fig. 5; the first being humerus, second ulna, third and fourth carpals (tarsals) the last phalanges, which are first specialized in this genus.

By far the most usual modification is however complication by duplicated and triplicated and still more highly multiplied repetition in some segments of the archetype, and its omission in other segments. Thus in in the *Tænia*, the cephalic segments are much modified, and the nature of its repetitions might be thus expressed:—Fig. 6; the simpler segments representing the body segment, the two complex, representing these of the head. In each, it will be observed, the complication is represented by loops of similar form, and each loop of dots which represent the cells in the first linear (fig. 1) arrangement.

A somewhat similar figure might represent the nature of the complication in the Myriapod. In the insect the additional complications of the thoracic segments would alter the diagram near the middle.

In the vertebrate cranium, a somewhat similar diagram might be used, except that the modification of the segments or vertebræ, as compared with the segments of the vertebral column, is not by repetition with modification of the parts of each segment, but rather by modification of the forms of the parts of the segments. The basi-cranial segments thus compare with the dorsal vertebræ as the segments of the limb of *Plesiosaurus* do to those of *Ichthyosaurus*.

The above considerations have reference to repetition of parts in a linear direction. Centrifugal repetition is seen in the addition of chambers to the heart, by the subdivision in the earliest stages into auricle and ventricle in the linear direction, considered in connection with the earlier division of each in the transverse direction, by the growth of partitions. This mode of repetitive addition is not readily represented by diagram.

A good example of repetitive addition in both linear and transverse direction, may be found in the successive complication of tooth structure seen in mammalia. In the dolphin, the dental series may be represented thus:—Fig. 7; in the squalodon thus:—Fig. 8; in the cat:—Fig. 9; in the dog:—Fig. 10; in man:—Fig. 11; in some insectivora:—Fig. 12.

The circles represented here, are each a simple cusp.

In conclusion, the directions of Repetitive growth may be tabulated as follows: The types to the left represent the original; to the right, the derivative.

Centrifugal.	Longitudin'l antero-posterior and bilateral.	More bilaterally symmetrical.	Only bilateral.
		More antero-posteriorly.	Only antero-posterior.
	Centrifugal.	In plane.	
		In globe.	

D. On Growth Force.

From such examples as those that precede, but more especially from the last, it seems necessary to believe that there resides in organized matter, and in its most unmodified representative, the nucleated cell, an affection which displays itself in repetition. This phenomenon reduced to its lowest terms, may mean cell-division only, but the proof is only clear in cases of growth proper. This affection displays itself in very slow or more rapid repetitions,—cell-division in growth occurring rapidly, while its recurrences at rutting seasons in the development of horns, feathers, etc., are separated by long intervals of time. In acceleration these repetitions occur with increased rapidity, *i.e.*, in the adding of more structures during the same growth periods, while in low types its repetitions are few and therefore slow.

What is the relation of cell division to the forces of nature, and to which of them as a cause is it to be referred, if to any? The animal organism transfers solar heat and the chemism of the food (protoplasm) to correlated amounts of heat, motion, electricity, light (phosphorescence), and nerve force. But cell-division is an affection of protoplasm distinct from any of these; although addition to homogeneous lumps or parts of protoplasm (as in that lowest animal, *Protamœba* of Hæckel,) should prove to be an exhibition of mere molecular force, or attraction, cell-division is certainly something distinct. It looks like an exhibition of another force, which may be called *growth force*. It is correlated to the other forces, for its exhibitions cease unless the protoplasm exhibiting it be fed.

Professor Henry pointed out many years ago that this must be the case, basing his belief on the observed phenomena of growth in the potato, and in the egg. The starch of the potato weighs much more than the young shoot of cellulose, etc., into which it has been converted by growth activity, so that a portion of the substance of the tuber has evidently escaped in some other direction. This is shown to be carbonic acid gas and water, derived from the slow combustion of the starch, which in thus running down from the complex organic state, to the more simple inorganic compounds, evolves an amount of force precisely equal in amount to the chemical force (or chemism) requisite to bind together the elements in the more complex substance.*

Carpenter also states that in his opinion the growth of the Fungi is produced by a force liberated by the retrograde metamorphosis of their food, which is of an organic character, (*i. e.*, humus). This metamorphosis consists, as in the tuber, in the production of carbonic acid gas and water, and a force equivalent to the chemism which had bound them in the former complex union.† But in higher forms of vegetable life and in growth that follows germination, the plant must appropriate carbon from the carbonic acid of the atmosphere. The decomposition of the

* Agricultural Report of the Patent Office. 1857.

† Correlation of Physical and Vital Forces, 1864, (Quarterly Journal of Science.)

binary compound (which sets free its oxygen) liberates the chemical force which had previously maintained the compound, (or an equivalent force) which Henry regards as furnishing the growth force, which produces the plant. Carpenter derives but a portion of the force in this way, obtaining the greater part from the heat of the sun. To this source also he looks for the *growth force* employed in the construction of cold-blooded animals; while in warm-blooded animals, the retrograde metamorphosis or running down of the material (protoplasm) of the food, furnishes a requisite amount of heat. Whether growth force be derived from the chemism set free, direct, or through the mediation of heat, by conversion, among higher animals, is a question yet unsolved.

Growth force we may then regard as potential in organized tissue, and as energetic during growth. Our present knowledge only permits us to believe that other force is only converted into it under the influence of pre-existent life, but of the real cause of this conversion we are as ignorant as in the case of the physical forces.

In the animal organism, different tissues display different degrees of "vitality." The most vital display cell-organization and its derivative forms, while the least so, approach nearer to homogeneity. As organized tissue is the machine for converting vital forces, we may believe that less growth force is potential in cartilage than in muscle, for it is formed by a retrograde process, by which cells once formed are mostly burst, and the contents form the intercellular, nearly structureless mass characteristic of this tissue. Growth force must be here liberated in some other form, perhaps heat, to be again converted to other use.

The higher vitality we may believe to result from the greater perfection of the more complex *machine* as a force converter, as compared with the inefficiency of the more simple.

E. On the Direction of Repetition.

It has been already pointed out that *growth force* exhibits itself in cell or segment repetition. The forms in which it thus displays itself may be briefly considered. The approximate cause is treated of in the next chapter; but enough may be shown here to indicate that duplication and complex duplication is the law of growth force, and that therefore this process must always follow *an increase in amount* in any given locality.

The size of a part is then dependent on the amount of cell-division or growth force, which has given it origin, and the number and shape of segments is due to the same cause. The whole question, then, of the creation of animal and vegetable types is reduced to one of the *amount and location of growth force.*

Repetition is of two kinds, *centrifugal* and *longitudinal*. As an example of the former, the genus *Actinophys* has been cited, where the animal is composed of cells arranged equidistally around a common centre. The arrangement in this type may be discoidal or globular, providing no definite axis be discoverable. As an example of *longitudinal* repetition, *Vibrio*, and numerous cellular plants may be cited where the arrangement is in a single line.

In by far the greater number of animals these kinds of repetitive structure coexist. The *longitudinal* is however predominant in the *Vertebrata*, *Mollusca* and *Articulata*, while the *centrifugal* is greatly developed in the *Cœlenterata* and *Radiata*. In none but the simplest forms, are either of these modes to be found alone.

The *centrifugal* repetition or addition, more nearly resembles the mode of aggregation of atoms in inorganic or crystalline bodies, and hence may be regarded as the inferior manifestation. It implies that growth force in this case conforms to a law of polarity in exhibiting itself at equal distances from a centre,—which is allied to ordinary molecular force, and independent of the localizing influences of which higher organisms seem capable. In centrifugal animals, then, the latter evidently plays an inferior part. In Cœlenterates and Radiates, however, the body possesses a short longitudinal axis, in some (*Asterias*) very short, in others (*Holothuria*), more elongate. The amount of complication of centrifugal growth greatly exceeds the complication in a longitudinal direction in all of these animals except the *Holothurida*.

It is now important to observe that great numbers of centrifugal animals are sedentary or sessile; while the longitudinal are vagrant, moving from place to place. Many of the centrifugal animals which wander, do not do so in in the direction of their axis, but sideways (*Medusæ*). It is also proper to notice that not only the movements of the muscles, but also the direction taken by the food is in the long axis. It is therefore to be concluded that in longitudinal animals growth force has assumed a more truly animal type, and that this tendency has predominated over the polar or molecular tendency.

In most longitudinal animals, however, certain lateral portions, limbs, etc., extend on each side of the axis; and were the space marked by their extremities, and those of the axis, filled, we would have the outline of a centrifugal animal.

Before discussing the influences which have increased and located growth force, it will be necessary to point out the mode in which these influences must necessarily have effected growth. Acceleration is only possible during the period of growth in animals, and during that time most of them are removed from the influence of physical or biological causes, either through their hidden lives or incapacity for the energetic performance of life functions. These influences must, then, have operated on the parents, and become energetic in the growing fœtus of the next generation. However little we may understand this mysterious process, it is nevertheless a fact. Says Murphy, "There is no act which may not become habitual, and there is no habit that may not be inherited." Materialized, this may be rendered—there is no act which does not direct growth force, and therefore there is no determination of growth force which may not become habitual; there is, then, no habitual determination of growth force which may not be inherited; and, of course, in a growing fœtus becomes at once energetic in the production of new structure in the direction inherited, which is acceleration.

But if the forces converted into growth force are derived from without the animal organism, whence and what the agency by which the acceleration or retardation of the latter is inherited from the parent? A few suggestions only on this head can be made in the fourth section.

III. THE LAW OF USE AND EFFORT.

Up to this point we have followed paths more or less distinctly traced in the field of nature. The positions taken appear to me either to have been demonstrated or to have a great balance of probability in their favor. In the closing part of this paper I shall indulge in more of hypothesis than heretofore.

Since repetitive addition only produces identical results in archetypes, and each effort produces results more and more unlike its predecessor as structure becomes specialized; it becomes important to examine into the influences which have originally modified the repetitive efforts successively, producing structures more or less different in detail in the second generation from those of the parents, in acceleration, or the reverse, in retardation.

Going further back, the question arises, why a simple exhibition of repetition (*e. g.*, cell division) should be converted into a complex or duplicated repetition (*e. g.*, jointed ray). This it has already been stated, is one consequence of increased amount of the growth force.

We then seek explanation of the main question, as to what determines the location of this additional or new growth force. (Div. A.)

Lastly, why the total amount of this force should change in a given individual or part of an individual. (Div. B.)

A. On the Location of Growth Force.

What are the influences locating growth force? The only efficient ones with which we are acquainted, are, first, physical and chemical causes; second, use; and I would add a third, viz: effort. I leave the first, as not especially prominent in the economy of type growth among animals, and confine myself to the two following. The effects of use are well known. We cannot use a muscle without increasing its bulk; we cannot long use the teeth in mastication without inducing a renewed deposit of dentine within the pulp-cavity to meet the encroachments of attrition. The hands of the laborer are always larger than those of men of other pursuits. Pathology furnishes us with a host of hypertrophies, exostoses, etc., produced by excessive use, or necessity for increased means of performing excessive work. The tendency, then, induced by use in the parent, is to add segments or cells to the organ used. Use thus determines the locality of new repetitions of parts already existing, and determines an increase of growth force at the same time, by the increase of food always accompanying increase of work done, in every animal.

But supposing there be no part or organ to use. Such must have been the condition of every animal prior to the appearance of an additional digit or limb or other useful element. It appears to me that the cause of the determination of growth force is not merely the irritation of the part

or organ used by contact with the objects of its use. This would seem to be the remote cause of the deposit of dentine in the used tooth; in the thickening epidermis of the hand of the laborer; in the wandering of the lymph-cells to the scarified cornea of the frog in Cohnheim's experiment. You cannot rub the sclerotica of the eye without producing an expansion of the capillary arteries and corresponding increase in the amount of nutritive fluid. But the case may be different in the muscles and other organs (as the pigment cells of reptiles and fishes) which are under the control of the volition of the animal. Here, and in many other instances which might be cited, it cannot be asserted that the nutrition of use is not under the direct control of the will through the mediation of nerve force. Therefore I am disposed to believe that growth force may be, through the motive force of the animal, as readily determined to a locality where an executive organ does not exist, as to the first segment or cell of such an organ already commenced, and that therefore effort is, in the order of time, the first factor in acceleration.

Addition and subtraction of growth force in accordance with the modes pointed out below, account for the existence of many characters which are not adaptive in their nature.

Acceleration under the influence of effort accounts for the existence of rudiments of organs in process of development, while rudiments of organs in process of extinction are results of retardation, occasioned by absolute or complementary loss of growth force. Many other characters will follow, at a distance, the modifications resulting from the operation of these laws.

Examples of the Influence of Physical Causes.

This is nowhere better seen than in the case of coloration, which requires the light of the sun for its production. The most striking examples of this are seen in the colorless surface of animals inhabiting the recesses of caves, as the blind craw-fish and the *Amblyopsis*, etc. If evolution be true, these have descended from more highly colored progenitors. The flat fishes, also (*Pleuronectidæ*) as is known, swim on one side in adult age, but many of them are hatched symmetrical fishes, or nearly so, one eye rotating from one side to the other by a twisting of the cranial bones. It is thus probable that they have descended from symmetrical fishes, which were similarly colored on both sides. Now, the lower side is colorless, the upper retaining often brilliant hues. The influence of sunlight is thus as distinctly discoverable among animals as among plants, where it has been generally accepted as a principal of vegetable physiology.*

Examples of the Effects of Effort and Use.

a The Respiratory and Circulatory System of Vertebrates. It is well known that the succession of classes of Vertebrates is measured first by

*In this and similar cases, care must be taken not to misunderstand the writer by supposing him to mean that in *each generation separately* the peculiar coloration is the result of changed exposure to light. The evolutionist will understand that the effect of such influence increases with succeeding generations by the addition to inherited character, of the effect of immediate external cause.

their adaptation to aëration in water, and then by their successive departures from this type in connection with the faculty of breathing air. The same succession of structure is traversed by the embryos of the vertebrates, the number of stages passed being measured by the final status of the adult. This transition takes place in the Batrachia later in development than in any other class. Now, it is well known that the transition or metamorphosis may be delayed or encouraged by suppression of use of the branchial and encouragement of use of the pulmonary organs or the reverse.

The aquatic respiration of tadpoles may be indefinitely prolonged by preventing their access to the surface, and it is known that in nature the size or age of the larva at time of metamorphosis may vary much in the same species. If perennibranchiates (*Siren e. g.*) are deprived of their branchiæ, they will aërate blood by the lungs exclusively, and there is no reason to doubt that by use of these, and disuse of the branchiæ, aërial respiration might become the habit of the animal. It is also easy to perceive that geologic changes would bring about a necessity for precisely this change of habit. This occurred in the period of the coal measures, where large fresh water areas were desiccated, and it was precisely at this period that many air breathing Batrachians originated and had a great development.

β The rattle of the Rattlesnake.

Nearly all of the larger harmless snakes which live on the ground have a habit of throwing the end of the tail into violent vibrations when alarmed or excited, with the view of alarming a supposed enemy. Among *Coronelline* snakes, *Ophibolus triangulus* possesses it; among the water snakes, *Tropidonotus sipedon*. In the typical Colubrine group the black snake, *Bascanium constrictor* is an example; *Pityophis sayi* also shakes the tail violently. The copperhead (*Ancistrodon contortrix*) and the moccasin (*A. piscivorus*) (fide Günther) have the habit in a marked degree. Among the rattlesnakes it is a means of both warning and defence, in connection with the rattle which they carry.

In the structure of the end of the tail of harmless snakes, we see a trace of the first button of the rattle in a horny cap that covers the terminal vertebræ.

In the venomous genera, it is conspicuous in *Lachesis* especially, reaching a considerable length and having a lateral groove. In the plate-headed rattlesnakes (*Crotalus*) this corneous cap is inflated into a button with lateral groove, and in some of them possesses only one or two buttons or joints. In the perfected rattlesnakes (*Caudisona*) not only are the segments numerous and inflated, but a number of the terminal caudal vertebræ are greatly enlarged vertically, and coössified into a mass.* This is important from the fact that the rattlesnakes are the most specialized of all snakes, standing at the head of the order, and as such, on the principal of *acceleration* present the greatest amount of *grade nutrition*.

Now it appears to me, that the constant habit of violent vibration in a

*See good figures of this structure in Zeitschr. f. Wissensch. Zoologie, VIII, Tab. 12.

part, tends to determine an increased amount of nutritive fluid to it, in other words to localize growth nutrition, and when this has attained complex repetition or grade nutrition, to result in new grade structure. (The segments of the rattle being nearly all alike, it is a case of simple repetition.) This view appears to be as reasonable as that generally entertained with regard to the cause of spavin in the horse's leg. Here, owing to excessive use, exostoses appear on the bones surrounding the tibio-tarsal articulation. As to the reason of the structure in question not appearing in forms lower in the scale than the rattlesnake, it is explained below, if the law of accumulation of grade nutrition be true. (See sec. B.) This is, that repetition (or acceleration) is only possible where the animal has an excess of growth force at its disposal, or can abstract it from some portion which is unused or useless.

γ *On horns.* The possession of horns on the posterior part of the cranium, as defenses against enemies is a character found in many distinct types of animals. (Herbivora have no (dental) weapons and need horns). It is seen in the *Batrachia Stegocephala* in the extinct genus *Ceraterpeton;* among *Anura* it is approached by *Triprion* and *Hemiphractus.* Among Reptilia it is well marked in *Phrynosoma,* a Lacertilian genus. In *Mammalia* the *Artiodactyla Ruminantia* are the horned animals of the order. We have opportunities of observing the habits of these representatives of the Frogs, the Lizards and the Mammals.

In the first case, any one who has kept ordinary toads and tree toads in confinement, is aware that when attacked and unable to escape, they defend themselves by presenting the top of the head forwards and using it as a shield. Now I have already pointed out* that in both toads, tree toads, and frogs, there are natural series of genera, measured by the degree of ossification of the superior cranial walls, the longest being that of the Hylidæ, which embraces six terms, viz: *Hylella, Hyla, Scytopis, Osteocephalus, Trachycephalus* and *Triprion.* The two last have the head thoroughly shielded, and *Triprion* has projecting angles which appear in some South American forms lately described by M. Espada, to be developed into short horns. That this excessive ossification is associated with the habit of protecting the whole body with the front, seems likely.

In the case of *Phrynosoma* we know that precisely the same habit is associated with the presence of the sharp horns; and that some genera without horns possess it also. *Phrynosoma* is an exceptionally sluggish genus in a family of most active forms, and must necessarily resort to this mode of defence more than they.

In the case of Ruminants, we also know that defence is accomplished by throwing the head down with the horns thrown forwards. But this is not confined to this group. That generalized suborder, the *Artiodactyla Ordinaria,* represented by the hog, which were no doubt the genetic predecessors of the Ruminants in time, also throw the head down in defence in the same way, having thus a manner totally distinct from that seen in

*Origin of Genera, 1868, p. 14.

the *Carnivora*. The latter show their *teeth* and often crouch preparatory to a leap.

These cases present so constant an association between habit and use, that admitting evolution, we are compelled to believe that the structure has given rise to the habit or the habit to the structure. In the former case, we have to suppose, with the author of natural selection, that among the many spontaneous variations, rudimental horns occasionally appeared, and that their possessors being thus favored in the struggle for existence, were preserved and multiplied; while those not favored, dwindled and were ultimately nearly all extirpated or starved. The question of origin is here left to chance, and Alfred Bennett has made a mathematical estimate of the chances of any particular profitable variation occurring among the great number of possibilities of the case. This has shown the chance to be so excessively small as to amount in most cases to a great improbability.

If we turn to the probabilities of such structure having arisen through the selection of that mode of defence by the animal, we find them greatly increased. The position occupied by the horns, in all the animals described, is that which is at once brought into contact with an enemy in conflict, and as sport among animals is a gentle imitation of conflict, the part would be constantly excited in sport as well. With an excess of growth nutrition, our knowledge of the effects of friction on the epidermis, and of excessive ligamentous strain and inflammation on bone (*e. g.*, spavin in horses) as well as of abnormal exostoses in general, would warrant us in the belief that the use of the angles of the parts in question in these animals, would result in a normal exostosis, of a simple kind in the frogs, or as horn cores in the Ruminantia. As to the sheathing of the cores in the *Bovidæ*, and nakedness in the *Cervidæ*, it is in curious relation to their habitat and to their habits. The epidermis and derm would of course share in the effects of friction. In the Bovidæ which dwell in treeless plains, or feed on the grasses in great part, the development of these coverings of the horn cores into a horny sheath, would naturally meet with no interruption. In the case of the deer, which mostly live in forests or browse on trees, constant contact with the latter would prevent the healthy growth of the dermal covering, and it would be liable to injury or constant excoriation by the animals themselves on the branches of trees, etc. This we know to be the present habit of the deer as regards the dermal covering of the horns. I have elsewhere pointed out the similar connection between the dental structure and habitat among the oxen and the deer. The former eating the harder grasses, are provided against the consequent rapid attrition of the tooth, by a prismatic form, which allows of more prolonged growth and more rapid protrusion. The deer, in accordance with their foliage-eating habits, do not wear the crown of the tooth with such rapidity. Long continued protrusion is not so necessary, hence the teeth are more distinctly rooted and have a prominence or shoulder, distinguishing the body of the crown.

B. Change in Amount of Growth Force.

1. *Absolute increase of Growth Force.*—As every type has had its period of greatest development in numbers, size, and complication of structure, the present law indicates as an explanation, a culmination of the process of conversion of growth force from its energetic to its potential state in tissue. The cause is primarily the increased exercise of effort and use, which while effecting a conversion, increases the capacity of the organs by which further conversion is effected.

2. *Local increase of Growth Force.*—Examples of a local increase of this kind are probably to be seen in convoluted organs; as the convolutions of the brain in higher Mammalia; the convolutions of the enamel of the Labyrinthodont Batrachia; the same phenomenon in the cotyledons or plumule of some seeds. In these cases the superficial area of the parts is excessively developed, and the inclosing organs not being proportionately enlarged, a convolution necessary follows. In the first case, the skull; in the second, the alveolus; in the third case, the seed-envelope, restrain the expanse of the contained part, which would otherwise follow increase of growth force.

3. *Absolute loss of Growth Force.*—This will follow defective nutrition, produced by inability of the animal to obtain heat and food requisite to that end. This is supposed to be due (according to the view hereafter proposed) primarily to deficiency of intelligence, in failing to adapt habits to changed physical circumstances, and secondarily to the unfavorable influence of such changed circumstances. The extinction of highly specialized types, which has closed so many lines of animal types, will be accounted for by their less degree of plasticity and want of capacity for change under such changed circumstances. Such changes consist of modified topography and temperature, with irruptions of many new forms of life by migration. The less developed forms would be most likely to experience modification of structure under a new order of things, and palæontology teaches that the predecessors of the characteristic types of one period were of the less specialized forms of that which went before.

Thus is explained the fact that, in following out the line of succession of animal forms we have constantly to retrace our steps from specialized extremes, (as osseous fishes, tailless Batrachia, song birds, etc.), to more generalized or simple forms, in order to advance beyond.

4. *The complementary diminution* of growth nutrition follows the excess of the same in a new locality or organ, of necessity, if the whole amount of which an animal is capable, be, as I believe, fixed. In this way are explained the cases of retardation of character seen in most higher types. The discovery of truly complementary parts is a matter of nice observation and experiment. Perhaps the following cases may be correctly explained.

A complementary loss of growth force may be seen in absence of superior incisor teeth and digits in ruminating Mammalia, where excessive force is evidently expended in the development of horns, and com-

plication of stomach and digestive organs. The excess devoted to the latter region may account for the lack of teeth at its anterior orifice, the mouth; otherwise, there appears to be no reason why the ruminating animals should not have the superior incisors as well developed as in the odd toed (Perissodactyl) Ungulates, many of which graze and browse. The loss to the osseous system in the subtraction of digits may be made up in the development of horns and horn-cores, the horn sheath being perhaps the complement of the lost hoofs. It is not proposed to assert that similar parts or organs are necessarily and in all groups complementary to each other. The horse has the bones of the feet still further reduced than the ox, and is nevertheless without horns. The expenditure of the complementary growth force may be sought elsewhere in this animal. The lateral digits of the *Equidæ* are successively retarded in their growth, their reduction being marked in *Hippotherium*, the last of the three-toed horses; it is accompanied by an almost coincident acceleration in the growth nutrition of the middle toe, which thus appears to be complementary to them.

The superior incisors of the *Artiodactyla* disappear coincidentally with the appearance of horns, which always exist in the toothless division of the order, except in some very small antelopes (*Cephalophus*, etc.) where the whole amount of growth force is small. Possibly the superior incisors and horns are complementary here. The retardation in development of the teeth in the higher apes and men, as compared with the lower apes is coincident with the increase of number of brain convolutions. That this is not necessarily coincident with reduction of teeth in other groups is plainly proven by the rodents and *Chiromys* where the loss of many teeth is complementary to the great size of the incisors of the middle pair. But in man there is no complementary increase of other teeth, and the reduction is no doubt due to contraction of the jaws, which is complementary to increase in other parts of the cranium, in both apes and men.

I am confident that the origin and loss of many structures may be accounted for in this way, and the correlation of parts to each other be *measured* accurately.

Objection. The first one which arises is that which the author of the Vestiges of Creation made against Lamarck's theory of a similar kind, *i. e.* that by assuming that effort, use and physical causes have originated modifications of structure, we give the adaptive principle too much to do. I have made the same objection to the theory of natural selection. It is true that an application to a purpose is involved in the present theory of the "location of growth force;" but in point of fact, a large number of non-adaptive characters are accounted for by it. These are the rudimental and transitional ones which mark the successive steps preliminary to the completion of an adaptive structure; second, those produced by deficiency of growth force in less favored regions of the body, and third and fourth, phenomena consequent on general deficiency and excess of growth force.

And it may be said in conclusion that if the three principles, or if use especially, should be found to be inadequate to the service here demanded of them, it may be at least said that they or the last named, constitute the only controllers of growth force to any degree at all, with which we are acquainted.

IV. ON GRADE INFLUENCE.

The object of the present section is the attempt to discuss how the influence of effort and use on the parent is placed in a position to be inherited by the offspring.

A. Of the Nature of Grade Influence.

In the first place, it is necessary to note the definition and character of grade influence.

α. Growth force uninfluenced by grade influence simply adds tissue either (*a*) in enlarging size, or (*b*) in replacing waste. It does this by repeating the cell, by division, in localities which have already assumed their specific form. This form of growth force may persist throughout life, but with diminished energy in age.

β. Grade influence directs growth force in building up the tissues into organs, and constructs the parts of the body successively to completion, the result expressing the type or grade of the animal or plant. Its energy terminates with maturity, except in cases of periodical reproduction of sexual ornaments of the male (birds, deer), where it continues throughout life, appearing at regular intervals.

But it has occurred in acceleration that instead of a simple repetition of the ultimate histological element of an organism, in adding to its amount, it adds a completely organized part of the structure, as a tube, a phalange, a digit, a limb or an arch; an ocellus or a tooth. For instance, in the genus *Amblystoma*, one section possesses four phalanges on the longest digit; another section exhibits but three. In the species *A. mavortium*, some individuals have the small number of phalanges, but the majority possess the larger number. As all are of common parentage a whole phalange has been lost or added. The explanation of this phenomenon is essential to the comprehension of the *origin* of type structures.

*In plants, growth nutrition continues throughout life, but in the higher plants it is more active during the earlier years in perennial species, additions to size becoming less and less marked with increasing age. Grade nutrition also persists throughout life, but is chiefly active during a short period only of every year, or during flowering and fruiting. Not only in the production of the reproductive organs, but also in the yearly additions to other typical parts of the plant, grade-nutrition is active.

**In animals, growth nutrition is more active in the early stages of life, but is continued throughout in the lower divisions; in the highest, it is also continued throughout life, but there is a greater contrast between its results during youth, when nearly the whole size is attained, and during age, where the additions are much less.

Grade nutrition is, on the other hand, entirely confined to infancy and youth, except in those low animals which produce their reproductive organs periodically (some *Entozoa*, etc.), where it may be said to be in nearly the same condition as in plants.

γ While the amount of growth force, potential in adult living animals, has varied very irregularly throughout the animal kingdom, there being large and small, simple and complex, in every division, it would seem to have accumulated on the whole, with the rising scale of animal types. Thus the lower or *Protozoa* are the smallest; *Radiates* are next in size; *Molluscs* and *Articulates* reach nearly the same maximum, which exceeds that of the *Radiates*, and falls far below that of the *Vertebrates*. Among the last the mammalia have attained as large if not larger size than any of the other orders (*e. g.*, *Cetacea*). This is, however, not necessary to the history of evolution.

That an increased amount of grade growth force has been constantly rendered potential, during the advance of time is clear, if the preceding inferences be true. It is also evident that some individuals have accumulated it more rapidly than others, if all alike originated from the simplest forms known to us. Multitudes have remained in the earliest stages (*Protozoa*) of the whole series, or of their own special series (*Lingula*), forming "persistent types;" or taken directions which rendered them incapable of expansion beyond a certain point without exhaustion or death; for example, complicated types, as *Ammonitidæ*. The quadrumanous animal which was the progenitor of man, may thus be believed to have acquired a higher capacity of this accumulation than his cotemporaries.

Assuming the nucleated cell to be the ultimate element of organic tissue, there are two types of life in which grade influence has not appeared, viz.: unicellular animals and plants, and living forms composed of homogeneous protoplasm. In the latter neither grade influence nor animal growth force is potential; in the former, simple growth force only. It is therefore apparent that grade influence has been developed in the organism itself; perhaps this may have been, in the plant, through the modified influence of external physical causes; in the animal, if our inductions as to use and effort be true, under the influence of the activities of the parent, which determined a structural change either in itself or in its offspring. The possibilities of this origin are considered in the next section.

δ. The *Location of Growth Force* proceeds under the direction of what Professor Henry calls "Vital influence." With this author I discard the use of the term "Vital Force," what was originally understood by that term being a complex of distinct ideas. The *Vital forces* are (nerve force) *Neurism*, (growth force) *Bathmism*, and (thought force) *Phrenism*.* All

*The objection of President Barnard to thought being an exhibition of a force, is that "thought cannot be measured." This objection does not take into consideration the two-fold nature of thought. The *amount* of thought can most assuredly be measured, the *quality* of the thought, in one view of the case, cannot. That part which cannot be measured is that which determines the *Location of thought force*, which, as in the case of growth force, is an attribute of the vital or other principle.

of these are supposed to be correlated to the Physical Forces, but are under direction and control of the *Vital principle* which locates their action, etc., just as molecular or *atomic constitution* determines the locality and character of the physical forces. The laws of the vital principle and of atomic constitution also determine the nature of the conversion of one force into another. Now, since physical and vital forces are correlated and convertible, the close relationship of the two controlling principles becomes obvious, and suggestive of their identity.

Dr. Carpenter, in describing the correlation of physical and vital forces, defines the difference of organic species to be similar to that prevailing between different chemical bodies (the latter depending on different molecular and atomic constitution), which leads them "*to behave* differently" from each other under similar circumstances. This may be more fully expressed by saying that different species possess different capacities for the location of the conversion of the physical forces into growth-force. A "descent with modifications" contemplated by a process of evolution, signifies a progressive change in this capacity. *Acceleration* means an increase in this capacity; *retardation* a diminution of it. *Grade influence* means the influence which has produced this change of capacity.

Precisely what the change consists in is a mystery, but that it is material in its character is rendered more probable the more we examine it.

B. The Origin of Grade Influence.

Living protoplasm can convert heat and nutriment into growth force without the agency of the nervous system. This is proven by the nutrition of the *Protozoa* and *Cœlenterata* and from experiments on the muscles of frogs, etc. In the latter case, as is well known, the nerve may be divided, and the muscle retain its size if a current of electricity be passed through it, thus sustaining the nutrition. As the presence and structure of the nervous system is in relation to the specialization of animal structure in other respects, it is very probable that the nervous system is in *higher* animals the agent of the *location* of growth force. In the lowest it is not effected by any such means. As the nervous system is the instrument of the metaphysical peculiarities of the animal (emotions, choice, etc.), we may conclude that in the lower animals, location of growth force is influenced by necessity without choice; in the higher by necessity with choice.

The impulses derived from the nervous system, it is known, may be reflex or automatic in consequence of application of stimuli from without. They may become so also, after having been originated consciously or by effort of will. In the case of habits, frequent exercise of choice has so impressed the nervous system as to result in its repetition of effort, often in opposition to changed choice.

The influence of effort in muscular action on the nervous system appears to be, first, to enable it to convert heat to nerve force, and, then, to conduct nerve force to the involuntary muscles or those controlling circulation, where it is converted into motion, which thus controls nutri-

tion through circulation. The nervous system, like others, develops in capacity with use, hence probably nerve tissue converts heat into nerve force as muscular tissue converts heat into motion. In other words, by repetition, the capacity of the nervous system for this conversion of heat is known to increase. As the amount of heat converted is in proportion to the amount of appropriate nerve tissue (see above) it is evident that use and effort increase the amount of nerve tissue.

The phenomena of thought render the same modification of structure probable. Effort in the direction of thought is supposed to convert heat into thought force. Inasmuch as the more intelligent animals possess the highest development of cerebral hemispheres, it is highly probable that brain substance converts heat into growth force also, which produces tissue of its own kind precisely as muscle does.

As different parts of the nervous centres, subserve different purposes, the development of these parts must proceed approximately under the influence of special kinds of effort and use. Where, as in the adult, heat is converted into growth force in the tissues to a very limited extent, if the above principles be true, the conversion of heat by the nervous system into nerve growth force and tissue, is on the other hand, not terminated.

Capacity for effecting conversion of force is regarded, as above pointed out, as dependent on molecular constitution. Hence we conclude that change in that capacity on the part of the nervous system involves a molecular change in its constitution.

Now, it is apparent that if the nervous centres possessed the enlarged capacities for the conversion of heat into nerve force and thus of constantly controlling the circulation in special directions, in a growing or fœtal animal, tissue will be produced in the directions in question. For the heat converted into motion in the adult is in the fœtus in large part converted into growth-force.

Now, we know physical and metaphysical peculiarities of parents to be inherited by offspring, hence, no doubt, the nervous structure determinative of growth force is inherited. This will then control the localities of special conversion of heat, etc., (from the mother) into growth force, in accordance with the structure of the parent, and the more decidedly, as its own increase progresses.

The result will be *acceleration*, or construction of tissues and organs in excess of those of the parent, if the effort or use devoted to a nerve or organ be represented in the nerve centre of the parent by a greater amount of force-converting tissue, than is necessary when inherited in the fœtus for the construction (by conversion), of tissues and organs like those of the parent.

That this is a partial explanation of inheritance, is rendered probable from the fact that, the types of structure presented by the nervous centres, express the grade of the animals possessing them far more nearly than those of any other organ or set of organs. If the brain, like other organs, develops by intelligent use, it cannot be doubted that this relation of its development to grade is not accidental, but that grade structure is an expression of its capacities, physical and mental.

C. On the Transmission of Grade Influence.

How force potential in nerve structure is inherited through the reproductive elements is a great mystery. The following considerations relate to it.

1. Secretion is known to be conducted through the conversion of heat into growth force, probably through the intervention of nerve force.

2. In many secretions which possess strong chemical qualities, as gastric juice, bile, saliva, etc., the fluid is formed by a destruction of the cells representing the efforts of growth force, which is therefore no doubt converted into chemism or chemical force.

3. In the spermatozoöids, which are produced by a process of secretion, the cells are not destroyed, and thus growth force remains potential; they exhibit however lively motions, which may represent motive force derived from the nervous centre.

4. While in contact with the yolk of the ovum, so long as vitality lasts, the motion must be communicated to portions with which it is in contact, or converted into one of the forces from which it was derived (heat) or into another force (growth force). The growth force potential in the cell of the spermatozoöid, on its destruction, becomes converted into heat or other force. Thus may originate the growth force of the ovum, which, once commenced, is continued through the period of growth. The process might be compared to the application of fire to a piece of wood. The force conversion is communicated to other material than that first inflamed. The new fuel in the case of the embryo, is the protoplasm derived from the mother.

V. ON INTELLIGENT SELECTION.

As neither use nor effort can be ascribed to plants, and as we know that their life history is much more dependent on their surroundings, than is that of animals, we naturally look to the physical and chemical causes as having a prime influence in the origination of their type structures. Without greater familiarity with the subject, I will not attempt to say how far the various degrees of growth force possessed by parent plants, located under the influence of meteoric and other surroundings, and preserved, destroyed or restricted by natural selection, may account for the characters of their successors of the present period. But other agencies similar to use, that is, automatic movements, may be also introduced as an element in the argument. The movements of tendrils seeking for support may be here considered, and as Dr. Asa Gray has pointed out, have consequences similar to those of use in animals. When the tendril seizes a support, growth force is located at the point of contact, for the tendril increases considerably in thickness.

Among animals of the lowest grade, movement must be quite similar to those of plants, or automatic from the start, and not even at the beginning under the influence of will. Evidence of will is, however, soon seen in the determinate movements of many of the Protozoa in the seiz-

ing of food. With *will* necessarily appears a *power of choice*, however limited in its lowest exhibitions, by the lack of suggestive metaphysical qualities, or the fewness of alternatives of action presented by surrounding circumstances, to animals of low and simple organism. We can, however, believe that the presence of greater or less number of external facilities for action, characterize different situations on the earth's surface, as well as that greater and less metaphysical capacity for perceiving and taking advantage of them, must exist in different individuals of every species of animal, however low, which possesses consciousness and will. These qualities will, of course, influence effort and use to the advantage of the animal, or the reverse.

Effort and use have very various immediate stimuli to their exertion.

Use of a part by an animal is either compulsory or optional. In either case, the use may be followed by an increase of nutrition under the influence of reflex action or of direct volition.

A compulsory use would naturally occur in new situations which take place apart from the control of the animal, where no alternatives are presented. Such a case would arise in a submergence of land where land animals might be imprisoned on an island or in swamps surrounded by water, and compelled to assume a more or less aquatic life. Another case which has also probably often occurred, would be when the enemies of a species should so increase as to compel a large number of the latter to combat who had previously escaped it.

In these cases, the structure produced would be necessarily adaptive. But the effect would sometimes be to destroy or injure the animals (retard them) thus brought into new situations and compelled to an additional struggle for existence, as has, no doubt, been the case in geologic history.

Direct compulsion would also exist where alternatives should be presented by nature, but of which the animal would not be sufficiently intelligent to take advantage.

Most situations in the struggle for existence, afford alternatives, and the most intelligent individuals of a species will take advantage of those most beneficial. Nevertheless, it is scarcely conceivable that any change or increase of effort, or use, could take place apart from compulsion derived from the relation of external circumstances, as a more or less remote cause.

Preservation, with modifications, would most probably ensue when change of stimulus should occur gradually, though change of structure might occur abruptly, under the law of *expression points*.*

Choice is influence not only by *intelligence*, but by the *imagination* and by the *emotions*.

Intelligence is a conservative principle, and always will direct effort and use into lines which will be beneficial to its possessor. Here we have the source of the fittest—*i. e.*, addition of parts by increase and location of

* See origin of Genera, p. 38.

growth force, directed by the will—the will being under the influence of various kinds of compulsion in the lower, and intelligent option among higher animals.

Thus, intelligent choice taking advantage of the successive evolution of physical conditions, may be regarded as the *originator of the fittest*, while natural selection is the tribunal to which all the results of accelerated growth are submitted. This preserves or destroys them, and determines the new points of departure on which accelerated growth shall build.

The influences locating growth force, may be tabulated as follows :

Division.	*Influence.*				
Plants.	Physical and chemical.	+ ? ?			
Plants with mechanical movements; animals with indeterminate movements.	"	+ use			
Animals with determinate movements or will, but no intelligence	"	"	+ effort under compulsion.		
Animals with will and less intelligence.	"	"	"	"	+ choice.
Animals with more intelligence.	"	"	"	"	+ intelligent choice.

As examples of intelligent selection, the modified organisms of the varieties of bees and ants must be regarded as striking cases. Had all in the hive or hill been modified alike, all soldiers, neuters, etc., the origin of the structures might have been thought to be compulsory; but varied and adapted as the different forms are to the wants of a community, the influence of intelligence is too obvious to be denied. The structural results are obtained in this case by a shorter road than by inheritance.

The selection of food offers an opportunity for the exercise of intelligence, and the adoption of means for obtaining it, still greater ones. It is here that intelligent selection proves its supremacy as a guide of use, and consequently of structure, to all the other agencies here proposed. The preference for vegetable or for animal food determined by the choice of individual animals among the omnivores, which were, no doubt, according to the palæontological record the predecessors of our herbivores, and perhaps of carnivores also, must have determined their course of life and thus all their parts, into those totally distinct directions. The choice of food under ground, on the ground, or in the trees would necessarily direct the uses of organs in the appropriate directions respectively.

In the selection of means of defence a minor range of choice is presented. The choice must be limited to the highest capabilities of the animal, since in defence, these will, as a general thing, be put forth. This will, however, not be necessarily the case, but will depend in some measure on the intelligence of the animal, as we readily observe in the case of domesticated species.

In the case of the rattlesnake, already cited, the habit of rapid vibra-

tion of the tail, appears to me to be the result of choice, and not of compulsion. For the cobra, of India, for the same purpose, expands the anterior ribs, forming a hood, which is a very different habit. Here are two alternatives, from which choice might be made, and violent hissing is a third, which the species of the colubrine genus *Pityophis*, have adopted to some purpose. As to the benefit of the rattle, it no doubt protects the animal from all foes other than man; but is rather a disadvantage as regards the latter, being by a beautiful turn of events a protection to the higher animal.

On the principal of natural selection it might be supposed that the harmless snakes which imitate the Crotalus for the sake of defence were preserved; but if the above explanation of the origin of the habit in the latter be true, the second explanation is not valid.

The power of metachrosis, or of changing the color at will, by the expansion under nerve influence of special pigment cells, exists in most *Reptilia*, *Batrachia* and fishes. It is then easy to believe that free choice should, under certain circumstances, so habitually avoid one or another color as to result finally in a loss of the power to produce it.

Thus, it appears to be a fact, that not only are species of fishes which dwell in the mud, of darker hues than those that inhabit clear water, but that individuals of the same species differ in a similar manner in relation to their habitats, those that live in impure or muddy waters having darker tints than those of clear streams.

Land animals present equally abundant and remarkable imitations of the objects or substances on which they live. This is well known in insects and spiders, which look like sticks or leaves, or the flowers on which they feed. It is seen in reptiles, which in very many cases can voluntarily assume the hue of leaf, stone or bark, or have constantly the gray color of their native desert sands.

These cases are largely selective or optional in their origin, for though metachrosis is also induced by some external stimulus, as an enemy or a food animal, yet other means of escaping the one and procuring the other, are generally open.

These facts pave the way for a consideration of the phenomenon of mimetic analogy which, though well known to naturalists, may be illustrated by the following new facts:

On the plains of Kansas, there is a species of *Mutilla* whose abdomen and thorax are colored ochraceous or brown-yellow, above. A spider of the genus *Salticus* is equally abundant, and is almost precisely similar in the color of the upper surfaces, so much so as to deceive any but a most careful observer. The *Mutilla* being a well armed insect, and a severe stinger, there can be no doubt that the *Salticus* derives considerable immunity from enemies from its resemblance.

On the same plains, the *Caudisona confluenta*, or prairie rattlesnake abounds. It is an olive grey, with a series of transverse brown dorsal spots, and two rows of smaller lateral ones. The head exhibits a num-

ber of brown and white bands. The prairie *Heterodon*, (*H. nasicus*) possesses not only the same tints but the same pattern of coloration, and at a short distance cannot be distinguished from it.

In consequence, as one may justly say, this species is, with the rattlesnake, the most common serpent of the plains, as it shares, no doubt, in the protection which the armature of the *Caudisona* gives its possessor. This is in accordance with the views of Wallace and Bates.

A curious case occurred to me in four species of fishes, which I took in a small tributary of the Yadkin River, in Roane County, N. C. Among several others, there were varieties of the widely distributed species *Chaenobryttus gillii*, *Hypsilepis analostanus* and *Ptychostomus pidiensis*, (each representing a different family), which differ from the typical form of each in the same manner, viz: in having the back and upper part of the sides with longitudinal black lines, produced by a line along the middle of each scale. This peculiarity I have not observed in these species from any other locality. Until I had examined them I thought them new species.

The only other species presenting such marking in the Yadkin River, is the large perch, the *Roccus lineatus*. According to the theory of natural selection a resemblance to this well armed species might be of advantage to the much weaker species in question; yet the same species co-exist in other rivers without presenting the same mimicry.

It is difficult not to urge the importance of the causes already regarded as efficient in the origination of structure, in the present branch of the subject also. We are especially disposed to call in use and effort here, after noticing how much more distinctly change of color is under the control of the animal, than change of shape. It must, however, be borne in mind that similar resemblances exist among plants; though, as Prof. Dyer shows, a large majority of these cases occur in species of different floral regions. Thus in this case, as in those of structure already cited, we appeal first to physical laws in the lowest beings, but with the increasing interference of use, effort and intelligence, as we rise in the scale. Thus it is that in the Vertebrates generally, the mimetic resemblances are found in species of the *same region*, where only an intelligent or emotional agency could be illustrated. If among animals as low as butterflies the influence of intelligence be denied, that of admiration for the beauty, or fear of the armature, of the predominant species imitated, would appear to be sufficient to account for the result. Admiration and fear are possessed by animals of very low organization, and with the instincts of hunger and reproduction, constitute the most intense metaphysical conditions of which they are capable. But our knowledge of this branch of the subject is less than it ought to be, for animals possess many mental attributes for which they get little credit.

It appears to be impossible to account for the highest illustrations of mimetic analogy in any other way, the supposition of Wallace that such forms must be spontaneously produced, and then preserved by natural

selection, being no explanation. It has been shown by Bennett that the chances of such modification arising out of the many possibilities are exceedingly small.

If the above positions be true, we have here also the theory of the development of intelligence and of other metaphysical traits. In accordance with it, each trait appropriates from the material world the means of perpetuating its exhibitions by constructing its instruments. These react by furnishing increased means of exercise of these qualities, which have thus grown to their full expression in man.

CRITIQUE.

1. *On the preceding essay.*—There will probably be found to be considerable resemblance and coincidence between the theory of Use and Effort, and the Lamarckian view of Development. The writer has never read Lamarck in French, nor seen a statement of his theory in English, except the very slight notices in the Origin of Species and Chambers' Encyclopædia, the latter subsequent to the first reading of this paper.

Darwin's only speculations as to the *origin* of new structures which are contained in his "Origin of Species" (Ed., 1860), so far as I can find, occur in the first and fifth chapters. In the first he says, discussing the variability of domesticated animals and plants, "I think we are driven to conclude that this greater variability is simply due to our domestic productions having been raised under conditions of life not so uniform as, and somewhat different from, those to which the parent species have been exposed under nature. There is also, I think, some probability in the view propounded by Andrew Knight that this variability may be partly connected with excess of food. * * * But I am strongly inclined to suspect that the most frequent cause of variability may be attributed to the male and female reproductive elements having been affected prior to the act of conception. * * Nothing is more easy than to tame an animal, and few things more difficult than to get it to breed freely under confinement, even in the many cases where the male and female unite," etc. Chapter V. repeats similar propositions but states that the effect of climate he believes to be small, but rather greater in plants than animals.

The view as to the impressibility of the reproductive element is taken up by Mivart, but the subject remains in the chaos of unshaped hypotheses.

2. *On the Origin of Genera.*—The memoir issued by the writer under the above name was chiefly devoted to the demonstration of the law of Acceleration and Retardation. A small portion was devoted to geographical and geological relations. It remains to correct two errors in the former portion of the book.

(1). It is there stated (p. 5) that the Law of Natural Selection of Darwin is as follows: "That the will of the animal applied to its body in the search for means of subsistence and protection from injuries, gradually produces those features which are evidently adaptive in their nature.

That in addition, a disposition to a general variation, on the part of the species, has been met by the greater or less adaptation of the results of such variation to the varying necessities of their respective situations. That the result of such conflict has been the extinction of those types that are not adapted to their immediate or changed conditions and the preservation of those that are."

It is unnecessary to state that the first sentence of the above does not express the theory of Darwin in any part or particular, while the two following do.

Further, it is stated (same page), "What we propose is, that of [generic characters] comparatively very few, in the whole range of animals and plants, are *adaptations* to external needs of forces, and that of specific characters a large proportion is of the same kind. How, then, could they owe their existence to a process regulated by adaptation?" Below, it is again said, "that while Natural Selection acts by the 'preservation of the fittest,' Acceleration and Retardation act without any reference to fitness at all; that instead of being controlled by fitness it is the controller of fitness."

Thus, from the existence of large numbers of non-adaptive characters I was induced to believe that an antagonism existed between the two laws. The present essay shews this to have been an error, and that by reconciling them, they become coördinate factors in producing the result. Thus "Acceleration and Retardation" is the "controller of fitness," because all adaptive structures are produced in accordance with it, and in no other way. The law of Intelligent Selection also prescribing fitness, removes it from the domain of physical or material necessity implied by Darwin's law of "Survival of the fittest." Adaptation therefore is the guide of change, though not the mechanically produced adaptation implied by natural selection. The disturbance of the balance of forces produced under its influence, leaves *growth force* to create primarily, the great number of unadaptive characters, which are simply *unfinished adaptive* ones, and secondarily, others occasioned by excess or loss of force in different directions.

The reconciliation of these laws and their complementary relations were perceived before the essay was completed, see in the recapitulation. Prop. II., p. 79.

(2.) Under the head of Heterology (p. 55), a number of groups are introduced as "Homologous" (as defined p. 54). Some of these I believe to be truly of this character, but some others are probably not so related, but are merely series of genera presenting similar structural peculiarities as consequences of the operation of identical laws. I would place under this head, and withdraw from the homologous class, the families of *Lacertilia Leptoglossa*, *Diploglossa* and *Typhlophthalmi*, those of the Old and New World *Quadrumana* and those of *Cephalopoda*.

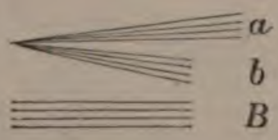


Fig. 13. (See p. 233.)

Catalogue of the Pythonomorpha *found in the Cretaceous Strata of Kansas.*

By E. D. Cope.

(Read before the American Philosophical Society, December 17th, 1871.)

The following brief review is prepared in consequence of the acquisition by the author of a considerable accession of material from the chalk of Western Kansas. Attention is confined to one order of Reptiles at present, owing to its predominant importance in the vertebrate fauna of that time and place, as is indicated by the great profusion of individual remains and specific forms. Although occurring in America wherever the Cretaceous formation appears, they are so far, more numerously represented in Kansas than elsewhere. Though not rare in New Jersey, crocodiles and tortoises outnumber them; but in Kansas, all other orders are subordinate to the *Pythonomorpha*. As is now well known since 1868* the seas of the American continent were the home of this order, while they were comparatively rare in those of Europe. In the latter country we have four species only determined by palaeontologists, viz:

Mosasaurus	2
Liodon	1
? Saurospondylus	1

In North America the species have been exactly determined from three regions, as follows:

Green Sand of New Jersey.

Mosasaurus	6
Baptosaurus	2
Clidastes	2
Liodon	4
(?) Diplotomodon	1
	15

Rotten Limestone, Alabama.

Mosasaurus	1
Holcodus	1
Liodon	3
Clidastes	2
	7

Chalk of Kansas.

Clidastes	3
Edestosaurus	4
Holcodus	4
Liodon	6
	17

* See Transactions Amer. Philo. Soc., Vol. XIV.

(*To be continued in No.* 88.)

The following Photographs have been received by the Society, for which the thanks of its Officers are tendered to the senders.

There are still many Members of the Society whose Cartes de Visite would find room in the Album, to beautify and complete the Record of its Membership.

Abbot, H. L.
Agassiz L.
Arfwedson, C. D. R.
Adams, J. C.
Bache, A. D.
Bache, Franklin
Baird, C. H.
Baird, S. F.
Bancker, C. N.
Barnes, Albert
Bancroft, John
Bancroft, Geo.
Bigelow, Jacob
Binney, Horace
Blackwell, C. T. E.
Böhtlingk, O.
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PROCEEDINGS

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making with the others from	
New Jersey	15
Alabama	7
Kansas	17
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Of these I am not acquainted with any which extends its range into any two of the areas above named, while some of the districts possess peculiar genera. It is nevertheless premature to draw any conclusions as to geographical range, as most of the species are known from but few specimens as yet.

Two genera have recently been discovered in Europe, which have been thought to be allied, or belong, to this order. One of these, *Acrodontosaurus* Hulke, rests on the anterior portion of a maxillary bone with part of premaxillary and teeth. These portions are indecisive as to its affinities. It is from the English Chalk. The second form is the *Danubiosaurus* of Bunzel, which its describer refers to the neighborhood of *Mosasaurus*. It is quite plain after an inspection of his description and figures, that it has no affinity to that genus or to the order *Pythonomorpha*. It is from Neue Welt, from the Cretaceous, near Vienna.

The present investigations have added some points of importance to the history of the structure of the order.

First, as to the pterygoid bones. It appears that these elements are thin plates, having a free laminar termination, and are entirely toothless. They articulate with the palatines by a process which fits their posterior emargination. In *Edestosaurus tortor*, they are about half the length of the palatines. They present no indications of ectopterygoid. The bones named by authors pterygoids, in imitation of Cuvier, are elongate palatines, and the external process extending to the maxillaries, is that seen in Varani, serpents, etc., and is at no time distinct from the palatines.

It has also shown that the supposition of Goldfuss and myself, that the palatines of *Mosasaurus* were in contact on the median line, is an error, and that they are more or less vertical plates, as in *Liodon*. The distinction between these genera, then, rests on the coössification of the chevron bones in the former, and their permanent independence in the latter; perhaps the difference in the form of the teeth may also count for something.

Second, as to the parieto-squamosal arch, which is distinctly developed in *Holcodus ictericus* and *Liodon curtirostris* in its parietal part and *H. coryphæus* in the squamosal part. It was quite strong in the species named.

Third, as to the pelvis. This part, which has been observed by Marsh

in *Edestosaurus dispar*, is usually perfect in *Liodon dyspelor*. The pubes are the only elements united below, forming a weak support to the abdomen. The ilia are slender, not united with vertebral processes above, or without indications of such contact. The ischia are the most slender and directed backwards.

Fourthly, in the hind limb. The femur of *L. crassartus* has been described by the writer, and Professor Marsh asserts its existence in *Liodon*, *Clidastes* and *Edestosaurus*. The present collection exhibits both femur, tibia and fibula of *L. dyspelor*, and these elements are now first described. The first mentioned is not larger, sometimes smaller than the humerus, and has a prominent trochanter, nearly connected with the head. The shaft is not curved, and the distal end is expanded. The tibia is a narrow bone expanded at both ends, the fibula is like that of *Plesiosaurus*, but wider, or partly discoid. It has been known to naturalists but not determined. Thus I figured it for *Liodon laevis*,* and Leidy figured it for an upper Missouri species.†

CLIDASTES, Cope.

Proc. Acad. Nat. Sci., Phila. 1868, p. 233. Trans. Amer. Philos. Soc. 1870, 211.

Vertebræ with the zygosphen articulation. [Palatine bones flat and alate, the teeth not exposed at their bases unequally. This point has not been observed in the type species, *C. iguanavus*.]

Clidastes cineriarum, Cope.

Proc. Amer. Philos. Soc., 1870, 583.

Several individuals from different points near the Smoky Hill River, Kansas.

The largest species.

Clidastes vymanii, Marsh.

Amer. Jour. Sci. Arts, June, 1871.

From two individuals from the Smoky Hill River and its North Fork.

A small species.

Clidastes pumilus, Marsh, l. c.

From one individual from the Smoky Hill River.

The smallest known Mosasauroid.

EDESTOSAURUS, Marsh.

Amer. Jour. Sci. Arts, 1871, June.

Vertebræ with the zygosphen articulation; palatine bones narrow, partly vertical, the bases of the pterygoid teeth exposed on one side, or pleurodont. (It is uncertain whether the type of *Clidastes* presents this structure or not.)

Edestosaurus tortor, Cope, sp. nov.

Vertebræ of the cervical and anterior dorsal regions with round articular faces, not emarginate for the spinal cord. The bodies are elongate

* Trans. Amer. Philos. Soc. 1869, 205. † (Cretaceous Reptiles,) U. S. Tab. viii. fig. 10.

and somewhat contracted, and marked everywhere with finer and coarser striæ. Hypapophyses prolonged on the cervicals, the free one of the atlas with a prolonged keel-like process.

Quadrate bone with long external angle and rather thick anterior ala with broad rugose margin. A prominent obtuse ridge is continued from the external angle to the inferior articular extremity, the distal portion being more acute. A rugose process projects at the point where the posterior hook approaches the body, and is continued as an elevated narrow ridge, parallel to the previously mentioned, to the distal articular surface. A button-like knob appears on the posterior margin of the hook opposite the meatal part. A strong ridge extends on the inner face of the bone from opposite the end of the hook to the base of the great ala. The distal articular surface presents two planes; the narrower at the end of the posterior pair of ridges above described; the larger considerably less distal, like a broad step.

The *maxillary bone* descends regularly in front, uniting with the premaxillary by a minute suture. Its posterior extremity is slender and acute.

The *premaxillary* is short conic, not particularly prominent. The *palatine bone* has a slight expansion on the inner side; on the outer the margin is very narrow.

The *teeth* number seventeen on the maxillary bone. They are compressed, least so anteriorly, and with a cutting edge from base to crown as far as the fifth from the front, in those anterior to that point the posterior edge is discontinued. There are sixteen pterygoid teeth which are smooth and without anterior cutting edge. The *frontal bone* has a low carina along the median line of its anterior portion.

		M.
Length of axis with odontoid process		.078
Diameter of ball of a cervical	vertical	.026
	transverse	.026
Expanse of diapophyses do.		.084
Length of centrum do.		.052
Length of maxillary bone		.363
" ramus mandibuli behind dentary		.31
Length of premaxillary		.04
Total of cranium (=2.33 feet)		.713
Length of pterygoid and palatine		.315
Length of centrum posterior dorsal vertebra		.066
Diameter of ball	vertical	.033
	transverse	.038

The bones of this species are all light and slender. The elongation of the vertebræ indicate that if their number was of the usual amount, the animal was of more than usually slender proportions. The position in which it was found was a partial coil, the head occupying the inside of a turn of the dorsal vertebræ. As compared with *E. dispar* and *E. velox* of Marsh, the present differs in the lack of depression of the centra of the

vertebræ, especially the anterior, and in various details of structure of the quadrate bones, as well as the larger number of teeth.

Discovered in Fossil Spring cañon in the grey limestone by Martin Hartwell and Sergeant Wm. Gardner. But one specimen was found, which includes the greater part of the cranium, with the vertebræ as far as the lumbar region.

EDESTOSAURUS STENOPS, Cope, sp. nov.

Indicated by a large part of the skeleton of one individual, and fragments of two others. The first includes a large part of the cranium, with both quadrates, and fifty vertebræ, including the axis. The characters are similar to those of the preceding species, but all the bones are more massive, though of the same dimensions.

The teeth are strongly compressed, with cutting edge fore and aft, and with the surfaces distinctly faceted; there are seventeen on the mandible. The palatine bones are stouter than in *E. tortor*, but the teeth are not larger, and are probably as numerous, as they are similarly spaced.

The *vertebræ* exhibit round articular surfaces, those of the dorsal region being rather stouter than the cervical, though the difference does not appear to be so marked as in the preceding species. The anterior caudals possess wide diapophyses. The articular faces are a vertical oval, a little contracted above, sometimes by a straight outline. They preserve a peculiarly elongate form.

The *quadrates*, like those of the last species, have a very prominent external angle. They present various differences which may be regarded as individual; for example, the edge of the great ala is not expanded outwards, but only inwards; the distal articular extremity is wider, the posteriorly decurved hook is more contracted, forming a deeper external concavity behind the external angle. Characters of more importance are the lack of the two ridges which bound the posterior face of the distal end of the bone, that face being thus convex instead of concave, and the process below the meatus is isolated and not continued into a ridge, except internally, when it gives rise to the heavy ridge which extends to the base of the great ala. The button on the posterior aspect of the hook is wanting, its place being taken by a recurvature of the smooth articular face along the margin.

		M.
Length of axis (above)		0.06
Diameter ball	vertical	.027
	horizontal	.027
Length of a posterior dorsal		.069
Diameter ball	vertical	.033
	transverse	.038
Length caudal with flat diapophysis		.033
Depth cup. do.		.031
Width cup, do.		.03
Length mandible (28 inches)		.720
Depth at coronoid process		.150
" " proximal end of dentary		.074
" " distal " "		.02

A fine specimen of this species was found by Martin V. Hartwell near Fossil Spring. Portions of a second were found by Lieut. Jas. H. Whitten on a bluff on Butte Creek.

Both the above species are the most elongate in proportion to their diameter of the order. They are larger in their dimensions than those next enumerated.

EDESTOSAURUS DISPAR, Marsh.

Amer. Jour. Sci. Arts, June, 1871. Smoky Hill River.

EDESTOSAURUS VELOX, Marsh, l. c.

Near the North Fork of the Smoky River.

HOLCODUS, Gibbes, Cope emend.

Vertebræ without the zygosphen articulation. Palatine bones flat, alate, its teeth not unequally exposed at the bases, or not pleurodont.

This genus bears the same relation as regards the palatine bones and teeth, to the genus *Liodon* that *Clidastes* does to *Edestosaurus*, as above defined. The structure of the caudal vertebræ I unfortunately cannot ascertain, and therefore do not know whether they are as in *Clidastes* or *Liodon*. It differs from *Mosasaurus* as it does from *Liodon*, i. e. in the horizontal laminiform palatines.

The name which I use for this genus was originally applied by Dr. Gibbes* of Charleston to a species represented by teeth from the cretaceous of Alabama, but of which no other portions were known. The teeth of the Kansas species now referred to this genus, are very similar in character to those described by Gibbes, so much so as to lead me to believe that when other portions of the *H. acutidens* of that author are known, they will be found to display the more important features here regarded as truly distinctive of the genus. Its place is evidently between *Clidastes* and *Liodon*, the pterygoid bones being those of the former, and the vertical articulations being identical with that characteristic of *Liodon*. In all of the species, traces of the zygosphen appear, but in the H. *coryphaeus*, Cope, the rudiment amounts to a short process directed forwards at the base of each anterior zygapophysis.

The species known as yet are of medium size in the order.

HOLCODUS CORYPHAEUS, Cope, sp. nov.

Characters. Cervical and dorsal vertebræ with the articular surfaces depressed transverse, slightly excavated above for the neural canal. The diapophyses not continued inferiorly to the rim of the cup, on the cervical vertebræ, and not receiving from it a cap of articular cartilage. Occipital crest much elevated, quadrate bone small, the meatal pit depressed between bounding ridges above and below. Rudimental zygosphen not uniting into a keel above. Teeth slender less curved than *H. ictericus.*

Description. This species is chiefly based on one specimen, which in-

* The *Mosasaurus* and allies: Smithsonian Contr. to Knowledge. 1851. 9 Plate.

cludes the greater part of the cranium and seventeen vertebræ, with ribs, Isolated portions of other individuals were also found in the same region of country.

The disproportion between the diameters of the cervical and dorsal vertebræ is more marked here than the species of *Edestosaurus*. The centra are less elongate, though with larger diameter. The cranium is relatively much smaller, the teeth absolutely smaller, though the quadrate bones are of equal size. The general character of the species is stouter, but less strongly armed, and less elegantly built.

The hypapophysis of the *atlas* has a short small keel below. The neural spine of the *axis* is elongate, but less so than in the two *Edestosauri*, truncate behind, with a median groove into which the anterior keel of the neural spine of the third cervical vertebra is applied. The diapophysis of this vertebræ has a short vertical articulating surface, and is continued into a longitudinal keel, which disappears before reaching the edge of the cup. The same process of the axis has a longitudinal parallelogrammic articular surface.

The *supraoccipital* is very thick and is roof-shaped, the keel rising nearly perpendicularly from the foramen magnum.

The *suspensoria* are directed both upwards and backwards, at about an angle of 45° in each direction, and support on their extremities the squamosal bones. These are prolonged, forming part of their appropriate arch. The occipital condyle is transversely oval. The *sphenoid* bone embraces as usual the basi-occipital protuberances; it is not carinate on the median line below. It sends out on each side near the anterior extremity a sub-horizontal laminar process.

The *quadrate* bone is much like that of *H. ictericus*, but is relatively smaller. While the teeth in that species are smaller, the quadrate is larger, hence the difference in the species is in this point quite striking. The external angle is prominent but very obtuse, and is the summit of a very thick obtuse ridge which extends to near the distal articular surface. The posterior hook is much prolonged downwards and has no button-like process or extension of the articular surface on its posterior face. This face presents a strong rib along the meatus and disappearing above the pit, throws the latter into a depression. This is increased by the swelling of the external angular rib. A prominent knob very rugose at the extremity rises beneath the end of the hook, and bounds a concavity between it and the external rib.

The latter closes the concavity by curving round towards the knob above mentioned. A keel rises exterior to the rib, and below it, and continues into the external angle of the articular extremity. Another very prominent keel extends from the knob beneath the hook to the base of the great ala. The articular extremity is transverse, and in one plane.

The *maxillary bone*, is marked with shallow longitudinal grooves. It supports eleven teeth and has a rather steep premaxillary suture descending in front. The nareal expansion in front occurs opposite the fourth tooth.

The *teeth* are rather long slender and incurved and recurved. There is a distinct cutting edge anteriorly and on a greater or less part of the length of the posterior face. The crowns are four or five faceted on the outer face; the inner face is more numerously faceted, and striate-grooved. The section at the base is sub-circular; higher, the outer face is flatter, the inner more convex. The apex is acute and the cutting edges strong.

The *frontal* is narrow, and differs from the other Holcodi here described in having the olfactory groove closed by contraction behind. Both *palatines* are preserved. They support twelve cylindric conic teeth which have recurved apices and striate enamel. The section is a flat transverse oval, where the external transverse process is given off. The shaft of the bone is much expanded inwardly with a thickened margin; exteriorly the margin is thin, and is nearly followed by the series of teeth, whose bases are exposed externally, and are therefore pleurodont. The emargination for the pterygoid is very deep.

	M.
Length of axis with odontoid	0.074
" third cervical	.048
Diameter ball, do. { vertical	.021
Diameter ball, do. { transverse	.033
Elevation of spine of do. from centrum	.046
Length posterior dorsal	.068
Diameter centrum { vertical	.033
Diameter centrum { transverse	.048
Length basioccipital and basisphenoid	.084
Elevation occipital crest above floor of foramen magnum	.03
Length suspensorium from foramen ovale	.09
Length os quadratum	.073
Width distal extremity	.036
Length os maxillare	.21
Depth do. at third tooth	.036
Length fourth tooth	.032
" of crown of do.	.021
Length of palatine bone	.155

This fossil was found by the writer projecting from the side of a bluff in a branch of the Fossil Spring Cañon near the mouth of Fox Cañon. The bluff was from 80 to 100 feet in height, and the *Holcodus* was taken from a position forty feet below the summit, from the yellow chalk.

HOLCODUS TECTULUS, Cope, sp. nov.

Established on a number of cervical and dorsal vertebræ of smaller size than those characteristic of the other species of the genus. The centra have not suffered from distortion under pressure. The articular surfaces are depressed transverse elliptic in outline, with a slight superior excavation for the neural canal. A well marked constriction surrounds the ball. There is a rudimental zygosphen in the form of an acute ridge rising from

the inner basis of the zygapophysis and uniting with its fellow of the other side forming a production of the roof of the neural canal. The combined keels become continuous with the anterior acute edge of the neural spine. Thus the form is quite different from that seen in the last described species, and constitutes a lower grade of rudiment. The fact that this zygosphenal roof is separated on each side from the zygapophyses by an acute groove, gives the former a distinctness more apparent than real.

The fixed hypapophyses are short and broad. The centra are not elongate. Those of the anterior dorsals present an obtuse keel below.

		M.
Length of a median cervical		0.043
Diameter of ball of do.	vertical	.02
	transverse	.033
Length of anterior dorsal		.042
Width of cup		.032

Found by the author on a low bluff or "break" on Butte Creek, fourteen miles south of Fort Wallace.

Holcodus icterictus, Cope.

Liodon ictericus, Cope, Proceed. Amer. Phil. Soc. 1870, p. 577. Hayden's Geol. Survey of Wyoming and adj. Terr. 1871.

In adition to the two individuals of this species procured by Professor B. F. Mudge in one of his geological surveys, the writer obtained a considerable part of a third from a low bluff on Fox Cañon, south of Fort Wallace. This includes seventeen lumbar, dorsal and cervical vertebræ including axis, with ribs, and a large part of the cranium with both quadrates, occipital and periotic regions, etc. Its characters may be briefly pointed out as follows :

Articular surfaces of dorsal and cervical vertebræ transverse oval, excavated above for neural canal ; diapophyses not extending below to the edge of the cup, hence not receiving an area of articular cartilage continuous with the rim. Occipital crest low, oblique. Quadrate bone larger, the meatus depressed between ridges. A button of articular surface on posterior face of hook. Scarcely any rudiment of zygosphen. Teeth small, much incurved, faceted and striate ridged.

Some characters additional to those already derived from the first known examples may be added. *The mandible* supports only twelve teeth. *The palatine* bone is shorter anterior to the external process, and longer behind it than in *H. coryphæus*. In our specimen, the posterior extremity is broken off, yet shows no indication of the emargination for the pterygoid bone an inch behind the position of its anterior extremity in *H. coryphæus*. There are ten teeth on the part preserved, four in front of transverse process (six in *H. coryphæus*), and six (probably seven) behind (six in *H. coryphæus*). The plate is more expanded than in the last named species, especially the thickened inner margin, which only ap-

proaches the basis of the last tooth ; (reaches the tooth line at the fifth in *H. coryphæus.*)

The *occipital* crest is low and directed obliquely forwards from the foramen magnum. The suspensoria are stout, and directed at an angle of 45° in both the superior ard posterior directions. The *basisphenoid* is strongly keeled below. The *quadratum* is like that of *H. coryphæus* in its massive external angle and ridge, but differs in the shorter hook and the non-interruption of the groove between the external angular ridge and the knob below the meatus. The cervical and dorsal *vertebræ* display the same disproportion in size, observed in *H. coryphæus.*

	M.
Length os quadratum	0.081
Width articular extremity of do.	.038
Length dentary bone	.28
" tooth of do. third from behind	.022
" " crown only	.016
" suspensorium from foramen ovale	.108
Total length cranium (23 in.)	.58

HOLCODUS MUDGEI, Cope.

Liodon mudgei, Cope, Proc. Am. Philos. Soc., 1870, 581. Hayden's Survey Wyoming, etc., 1871, p. 581.

The specimen of this species obtained by Professor Mudge on the Smoky Hill River, is the only one known to the writer. The characters distinguishing it are the following :

Vertebræ without rudimental zygosphen. Quadrate bone with plane surfaces from the proximal articular surface and the external obtuse angled ridge to the meatal pit ; the latter therefore not sunk in a depression as the other species.

The frontal bone is like that of *H. ictericus*, furnished with an open olfactory groove on the inferior face ; it is wider over the orbits.

A re-examination of the vertebræ of the type specimen, which I described as having compressed centra, renders it probable that they have been so modified by pressure as to render their normal shape a matter of uncertainty.

LIODON, Owen, Cope, emend.

Trans. Am. Philos. Soc., 1870, p. 200.

Vertebræ withont zygosphen and zygantrum. Palatine bones separated from each other, narrowed, the teeth more or less pleurodont. Chevron bones articulated freely with the caudal vertebræ.

This genus embraces several species from the Kansas Chalk, which range in size from the most usual in the last genus, to the largest known in the order.

LIODON CURTIROSTRIS, Cope, sp. nov.

Characters. Cervical and dorsal vertebræ with transversely oval articular faces, which are little depressed, and though not continued to the

neural arch, are scarcely excavated above for the neural canal. The diapophysis with stout inferior horizontal branch, which is capped by an extension of the articular catilage from the rim of the cup. Occipital crest elevated, sub-vertical. Quadrate broad below; pit sunk between bounding ridges.

Description. There is a great disproportion in the sizes of the cervical and posterior dorsal vertebræ; the centra of the latter are rather more depressed than those of the former. They are similar in proportion to those of the *Holcodi* and shorter than those of the *Edestosauri.* The short axes of the articular faces are sub-vertical. The rudiment of zygosphen is seen in the slight anterior prolongation of the roof of the neural canal. The keel of the hypapophysis of the atlas is short and obtuse.

The greater part of the *cranium* is preserved. The supra-occipital keel is vertical and furnished at the summit with a plicate knob for the insertion of a *ligamentum nuchæ.* The thickness of the walls of the bone is not equal to that in *H. coryphæus* and the suture is a double squamosal *i. e.* with groove along the middle of the edge. The basisphenoid is but slightly keeled below, and is distally expanded into a horizontal plate on each side. The parietals are, as usual, confluent, and send off two light arches postero-laterally for union with the squamosal bone. Between their origins are two sub parallel ridges which disappear, the transverse section of the narrow part of the parietals being rounded. The lateral ridges within the temporal fossæ are obsolete, while the convergent angles which bound the parietal table posteriorly are strongly marked: This table is nearly plane and the *foramen parietale* is large. The *frontal* is narrowed in front, and has an elevated keel along its anterior half. The olfactory groove is not much contracted behind, but is closed by the apex of the rugose area in front of the *foramen parietale.*

The palatine bone is narrow and the external margin is very slight, the bases of the teeth being exposed in that direction. The inner margin is much thickened downwards, but not so as to be a vertical plate. The hinder part of the bone is flat and horizontal, with a long maxillary process. The pterygoid notch falls opposite the second tooth from behind. The whole number of teeth is eleven.

The *jaws* are represented by the greater part of all of the tooth-bearing portions. The maxillary bone is shallowly sulcate on the exterior face. Its proportions are quite similar to those of the *H. coryphæus*, but the teeth it supports are larger and fewer. There are none missing from the extremities of the specimen, the whole number being ten; in *H. corphyæus* there are eleven. The crowns are incurved, faceted externally, and striate-grooved internally; there are cutting edges on front and rear, both strongest near the apex; the anterior continued to the base, the latter wanting on the basal third on median maxillaries. The anterior nareal expanse marks the fourth tooth from the *premaxillary* suture. The *premaxillary* bone is remarkable for its shortness and flatness at the extremity, this part being depressed and scarcely projecting at the lower margin in front of the anterior teeth. These as usual number four.

Both *quadrate* bones are preserved nearly entire. They have the same general character as those of *H. ictericus* and *H. coryphæus*, resembling rather the latter in the great length of the posterior hook, which is without posterior marginal button. The proximal external angle is large and obtuse, and is continued into a prominent thick ridge. The latter divides below, the thick extremity turning inwards and ceasing; an acute ridge continuing outwards and joining the exterior acute extremity of the distal articular surface. The submeatal knob is broad and thick, and not prominent, and its extremity turns at an acute angle forwards on the inner face and forms the commencement of the great ala. The articular surface is straight crescentic with an expansion on a tuberosity on the outer face (concave of crescent). The meatal pit is sunk between the ridges surrounding, one of which is on the outer margin of the posterior hook.

The *mandible* is nearly perfect. The dentary bone bears thirteen teeth, and at the extremity is contracted in both directions, and not prolonged beyond the base of the last tooth. The ridge which descends from the cotylus along the inner face of the articular bone, is not nearly so strong as in the *H. mudgei*.

	M.
Length axis with odontoid	0.062.
Elevation neural spine of do. at middle	.046
Length third cervical (body)	.05
Diameter ball { vertical	.025
Diameter ball { horizontal	.032
Length posterior dorsal	.065
Diameter ball { vertical	.038
Diameter ball { horizontal	.05
Length basis cranii	.09
" suspensorium	.105
Elevation occipital crest above floor foramen magnum	.045
Length tooth line pterygoid	.115
" maxillary bone	.21
" premaxillary laterally	.035
Width " " at second tooth	.041
Length dentary	.245
" maxillary tooth	.03
" " " crown only	.023
" os quadratum	.077
Width " " distally	.045
Length parietal	.085
" frontal to nares (median)	.11
Width " between orbits	.077
Total length of cranium (18.75 inches)	.473

The specimen above described was found by the writer on the denuded foot of a bluff on the lower part of Fossil Spring Cañon. The posterior part of the cranium with several vertebræ were found exposed, and many

other bones, including the cranium were found only covered by the superficial washed material. Other portions were exposed on excavating the blue grey bed of the side of the spur adjoining.

The name has reference to the abbreviation of the head and jaws.

LIODON GLANDIFERUS, Cope, sp. nov.

This species is represented by portions of two individuals from localities twenty-five miles apart. These are unfortunately in each case only a cervical vertebra, but they agree in possessing such peculiarities as distinguish them widely from anything yet known to the writer.

One is an anterior, the other a posterior cervical. The articular surfaces are transversely elliptic, and completely rounded above, that is, neither truncated nor excavated for the neural canal. Their vertical axes are oblique, *i. e.*, make less than a right angle with the long axis of the centrum, and the articular surface of the ball is thus carried forward, on the upper face, to much nearer the base of the neurapophyses than usual, in the anterior vertebra nearly touching them. The ball is likewise more convex than in any other species, having a slight central prominence in the posterior vertebra. There is no annular groove round the ball. In both, the articular surface of the hypapophysis is truncate and bounded by an elevation in front, a peculiarity not observed in any of the species already described. There is no trace of zygosphen in either. In the anterior vertebra the diapophyses are nearly horizontal, the posterior portion slightly thickened and oblique. The anterior portion is thinned out and very rugose above and below, and does not continue its margin into the rim of the cup. In the second vertebra, the diapophyses are very large, vertical and with a horizontal portion rising in a curve to join the middle of the lateral margin of the cup. Neural spine narrowed upwards keeled behind.

		M.
Length centrum anterior vertebra		0.064
Diameter ball	vertical	.03
	transverse	.039
Length of posterior		.064
Diameter ball	vertical	.03
	horizontal	.043
Expanse of anterior zygapophyses		.055

The first vertebra was found by the writer at the foot of a bluff on the lower part of the Butte Creek; the second was procured by Professor B. F. Mudge from a point one mile south-east of Sheridan near the North Fork of the Smoky River.

It is this species that I compared with the *Mosasaurus depressus*, Cope, in a report on the collection made by Professor Mudge (Amer. Philos. Soc., 1871, 168 Proceedings). The size is similar, but the form of the articular surfaces is very different.

LIODON LATISPINUS, Cope.

Proceed. Amer. Philos. Soc. 1871, p. 169.

This is a large species, nearly equaling the *L. mitchellii* in its dimensions.

that is forty or fifty feet in length. The remains representing it consist of seven cervical and dorsal vertebræ, five of them being continuous and enclosed in a clay concretion.

These display the elongate character seen in *L. laevis*, etc., but the articular surfaces are transversely oval, thus resembling the *L. ictericus*. they are less depressed than in *L. perlatus* and *L. dyspelor*. The cup and ball of the penultimate cervical are a little more transverse than those of the fourth dorsal, and none of them are excavated above by the neural canal. The last cervical is strongly keeled on the middle line below, and with a short obtuse hypopophysis marking the beginning of the posterior third of the length; the median line of the first dorsal has an obtuse ridge. There is no keel on the fourth dorsal, but the lower surface is concave in the antero-posterior direction. The diapophyses on the last two cervical and three first dorsal vertebræ have great vertical extent; the articular surface for the rib is not bent at right angles on the first dorsal. Neural arches and spines are well preserved in most of the specimens. There is no trace of zygantrum. The neural spines are flat, and have considerable antero-posterior extent on cervical as well as dorsal vertebræ, and are truncate above. The first dorsal bears a long strong rib.

	M.
Transverse diameter cup penultimate cervical vertebra	.051
Vertical diameter of same	.041
Length centrum fourth dorsal, without ball	.072
Vertical diameter ball	.0455
Transverse do.	.0555
Elevation front margin neural spine penultimate cervical	.088
Antero-posterior diameter do. do. do.	.05

There are smooth bands around the balls, and the surfaces of the centra are striate to these.

The depressed cups of the cervicals and anterior dorsals distinguish this species from the *L. validus*, *L. proriger* and *H. mudgei*. The same elements are much larger and more elongate than in *L. ictericus*.

It differs especially from these species of *Holcodus* and from *Liodon curtirostris* in the elongate form of the anterior dorsals; in the latter, they are much shorter and in three of them at least, the inferior limb of the diapophysis is turned forwards to meet the rim of the cup, while this feature ceases with the last cervical in *L. latispinus*. The articular surfaces have planes at right angles to the axis of the centrum and are not prolonged above as in *L. glandiferus*. The last hypapophysis is very short, with the anterior margin transverse and elevated as in the last named species.

In size, this species is intermediate between such gigantic forms as *L. dyspelor*, and the lesser *L. curtirostris*.

The type specimens were found by Professor B. F. Mudge, one mile south-west of Sheridan near the "Gypsum Buttes."

LIODON CRASSARTUS, Cope, sp. nov.

Liodon large species near L. proriger, Cope, Proc. Am. Philos. Soc., 1871, p. 168.

This saurian, which is similar in size to the last, is represented by a series of dorsal lumbar and caudal vertebræ with some bones of the limbs.

The vertebræ are as much distinguished for their shortness, as those of *L. latispinus* are for their elongation. The articular faces are but little broader than deep, and their axes are slightly oblique. They are very slightly truncate above by the neural canal. The inferior face is somewhat concave in the longitudinal direction. The zygapophyses are stout and there are no distinct rudiments of zygospen.

The dorsal vertebræ best preserved are those in which the diapophyses reach the middle of the sides of the centra, and have no horizontal limb. They are narrow and have not extensive articular extremital surfaces.

The lumbars and anterior caudals have round articular surfaces. One of the latter with strong diapophyses but posterior, is sub-pentagonal in outline of cup. The humerus is a remarkable bone having the outline of that of *Clidastes propython*, Cope, but is very much stouter, the antero-posterior dimensions of the proximal extremity being greatly enlarged. The long diameters of the two extremities are in fact nearly at right angles, instead of in the same plane; and the outline of the proximal is subtriangular, one of the angles being prolonged into a strong deltoid crest on the outer face of the bone, which extends half its length. The inner or posterior distal angle is much produced, while the distal extremity is a flat slightly curved diamond-shaped surface. The fibula is as broad as long and three-quarters of a disc. The phalanges are stout, thick and depressed, thus differing much from those of *Liodon ictericus*. A bone which I cannot assign any other position than that of femur has a peculiar form. It is a stout bone, but more slender than the humerus. The shaft is contracted and subtrilateral in section. The extremities are flattened, expanded in directions transverse to each other, the proximal having, however, a lesser expansion, in the plane of the distal end. The former has, therefore, the form of an equilateral spherical triangle, the apex enclosing a lateral fossa, and representing probably the great trochanter. The distal extremity is a transverse and convex oval.

This bone is either ulna, femur, or tibia, judging by form alone. Its greater length as compared with the fibula, forbids its reference to the last; the trochanter-like process of the head is exceedingly unlike any examples of the second bone I have seen. Its reference to femur is confirmed by its presence with the caudal-vertebræ of a similar species from near the Missouri River, Nebraska, and its resemblance to the femur of *L. dyspelor*.

	M.
Length humerus	0.10
Proximal diameter do	.095
Distal " "	.102

	M.
Length femur	.08
Proximal diameter do	.065
Median " "	.035
Length centrum dorsal vertebra without ball	.061
Transverse diameter cup	.06
Vertical " "	.053
Length of a lumbar (total)	.055
Diameter ball do (transverse)	.06
Length caudal	.041
Depth ball do	.052
Width do do	.052

The form of the humerus is something like that of *Ichthyosaurus*. Both this element and the femur are remarkable for their small size. They are scarcely half the dimensions of the elements of the anterior limb of *Holcodus ictericus*, and are even less than those of *L. dyspelor* in proportion to the animal's size.

It is unnecessary to compare this species with any but the *Liodon proriger*. Of this species, I unfortunately do not possess any of the limb bones, and must rely for comparison on vertebræ alone. The type specimen lacks the dorsals, hence the caudals alone remain for comparison. This shows that they are three or four times as large as the same proportions of the *L. crassartus*. In a smaller specimen of *L. proriger*, the dorsals are preserved, but so crushed as to be little available for measurements. One point besides the greater size is noticeable, their generally more elongate form, and the distinct superior emargination for the neural canal.

The remains above described were obtained by Professer B. F. Mudge, near Eagle tail, in Colorado, a few miles west of the line separating that Territory from the State of Kansas.

A series of twenty-nine caudal vertebræ with and without diapophyses, from a bluff on Butte Creek belongs perhaps to this species. The proximal specimens at least, cannot be distinguished from those of Professor Mudge's collection. The distal ones cannot readily be distinguished from the terminal ones of *L. proriger*.

LIODON PRORIGER, Cope.

Proc. Acad. Nat. Sci., 1869, 123. Trans. Am. Philos. Soc., 1870, 202.

This is the most abundant of the large species of the Kansas chalk. The writer found a muzzle consisting of premaxillary, and portions of maxillary and dentary bones, in a spur of the lower bluffs of Butte Creek, and numerous fragments of cranium and vertebræ on a denuded tract in the same neighborhood. Both of these belonged to individuals of smaller size than the type, the opportunity of examining which I owe to Professor Agassiz. The more complete Butte Creek specimen belongs to a huge animal; the size is grandly displayed by a complete premaxillary bone with its projecting snout, and large fragments of the maxillary. These

furnish characters confirmatory of those already given as above. The vertebræ are remarkable examples of flattening under pressure, without fracture, some of them having a vertical diameter no greater than one's hand. The cervicals are less flattened and give the impression that they were not transversely elliptic. This is consistent with our knowledge of the perfect specimen, where it is as described, furnished with vertically ovate articular surfaces. In this the cup is symmetrical and not distorted, but the ball is a little compressed by pressure,

The most important addition to the knowledge of this species, furnished by the Butte Creek specimen, is the character of the quadrate bone. The external longitudinal angular ridge is very prominent and extends to the distal end. It supports a hook-like prolongation of the proximal articular surface, almost as large a one as in *Clidastes propython* and more narrowed. The ridge is so prominent as to create a wider face or surface, behind the basis of the great ala than exists between the latter and the edge of the articular meatus. This basis is quite convex outward and embraces a relatively smaller space than in other Pythonomorpha. A section of the bone at the meatus is subtrilateral with a notch behind. The distal articular surface is prolonged below the origin of the great ala, and receives the keeled termination of the external ridge.

	M.
Total length quadrate	0.153
Length from superior to inferior origin of great ala	.08
Length external angle from bases of ala	.052

The two usual ridges pass inward and downwards from the meatal knob.

The above quadrates are flattened from within outwardly by pressure.

A portion of the palatine bone, supporting these teeth, displays the characters of the type, viz.: the inner face vertical and deeper than the outer, and forming a strong parapet of bone on the superior or toothless aspect. The outer face a little expanded laterally : the bases of the teeth exposed.

It is proper to add, that the locality ascribed to the type specimen "near Fort Hays, Kansas," which was given me on inquiry, is probably erroneous, Fort Wallace being the point intended.

LIODON DYSPELOR, Cope.

Proced. Amer. Philos, Soc., 1870, 574 ; 1871, 168, 172.

This large reptile was first described from specimens sent to the Smithsonian Institution from New Mexico. Professor Mudge subsequently obtained it in Kansas, and on my late expedition I had the good fortune to procure a large portion of another, on a sloping bluff on Butte Creek, fourteen miles south of Fort Wallace. This specimen is one of the most instructive which has yet been discovered, including as it does fifty vertebræ from all parts of the column, a large part of the cranium with teeth and both quadrate bones; the scapular arch complete, except lack of coracoid on one side, both humeri, radius and numerous phalanges of

fore limb; the pelvic arch complete with one hind limb complete to tarsus, with phalanges. The premaxillary is wanting, but the adjacent suture of the maxillary remains.

The *fronto-nasal septum* is convex in transverse section. The *maxillary* bone is much attenuated anteriorly, and supports thirteen teeth. The *ramus mandibuli* is high and slender; the angle is quite produced, and the median articulation indicates considerable mobility. The *palatine* bones are narrower than in any of the species previously described. They are deeply notched for union with the pterygoids, and the superior posterior process terminates in an acute cone. In front of the articulation, the bone is a vertical plate slightly concave on the inner side; the anterior half is subquadrate in section, the outer face subvertical, the inner, regularly rounded. The inferior surface is marked with a groove which passes from the inner side to the outer. The portion on the outer side of this groove, is on the distal third of the bone produced downwards into a prominent keel or ridge. The anterior extremity is an acute point. Each bone bears eleven teeth, all of which have the external faces of their roots exposed. The bones are curved outwardly from the fourth tooth from behind; opposite the sixth there is longitudinal concavity on the inner face.

The occipital region and suspensoria are not present, but both, *quadrates* were found perfectly preserved excepting the thin ala. They present marked characters, being most nearly allied to those of *L. proriger* and *L. validus*. The proximal articular surface exhibits an obliquity in the transverse direction. It presents a large external angle which instead of being nearly at right angles to the axis of the main portion of the surface, is nearly in the same line. The decurved posterior hook is very short. The distal articular surface has, like that of other *Liodons*, a small transverse extent, and is divided by a concavity into two tuberosities. The outer of these receives at its angle the prominent narrow portion of the external ridge, which extends from the external proximal angle. The prominence of this ridge is greater than in any other species except *L. proriger*; it is acute throughout its length and has a gentle sigmoid flexure. The basis of the great ala includes a smaller area than usual and is continuous with a prominent narrow ridge which proceeds from inside the metal crest. The metal crest takes the place of the "knob" in such *Mosasauri* as *M. dekayi*, it projects strongly backwards and outwards as an angle of two ridges; the inferior being acute and curved and terminating above the middle of the distal condyles. The meatal pit is not concealed between ridges, but is external; its form is peculiar, being a narrow oval, three times as long as wide, directed downwards and forwards. Thus the characters of this element are well marked among those pertaining to the other species.

The *teeth* are not much compressed, and have a cutting angle on the anterior and posterior margins, which separate nearly equal faces.

The *vertebral centra* change in form from the anterior to the posterior

regions. The ball of the axis is round, those of the vertebræ early suc ceeding are moderately depressed. The balls of the dorsals are transvers elliptic with a slight concavity for the neural canal; the plane a little ob lique to that of the long axis. The centra are more depressed posteriorl where the balls of the dorsals present rounded lateral *angles*. On the lum bars preceding the caudals, the base of the neural canal becomes mor elevated, and the articular faces assume a slightly pentagonal outline This form continues as far as our specimens of caudals extend. On thre lumbars, the centra present two longitudinal angular ridges below, a whose posterior ends the chevron articular surfaces appear on the firs caudals. All present an incised marginal groove to the ball. The sur face, especially the inferior, is strongly rugose up to this groove, espe cially on the dorsals.

The *axis* is much shorter than in any other species here noted, wher known. The neural spine has a very oblique superior margin and is ex panded behind. The diapophyses are narrow, and continued as vertica plates to the inferior face of the centrum at its anterior margin. Th diapophyses of the other cervicals have the usual horizontal limb, whicl is, however, shorter than the vertical. In the anterior dorsals, they ar directed more obliquely upwards and are longer. These, and all othe dorsals, maintain a connection between the rim of the cup, and th anterior basis of the diapophysis by a smooth area apparently cappe by cartilage in life, as exists in *L. curtirostris*. As we pass posteriorl these processes descend, and become narrower, until finally they thin ou and lengthen into the ribless diapophysis of the lumbars. Those of th caudals are long and subcylindric. Their extremities are deeply striat grooved. The neural spines of all the vertebræ are longitudinaly striat keeled. The zygapophyses are remarkable for their narrow form an surfaces. The *atlas* is shorter on the outer, and longer on the inner fac than in *L. validus*. This is caused by the fact that the posterior articu lar face is not transverse, but very oblique, and instead of being vertica and narrow, is obliquely longitudinal in its long axis. It is separate from the inner face by a wide rugose groove behind; its lower edge send a keel downwards. There is no process at the thinned infero-anterio angle.

The *scapular arch* was small especially the scapula, which is absolutel smaller than that of the *Holcodus ictericus*, a very much smaller reptile The posterior margin is thickened, the anterior thinner, and less elevated The superior is arched upwards and backwards. The general form is les oblique than in *L. ictericus*. The *coracoid* is twice as large, and is fla and thin. Its inner margin is regularly convex, the posterior concav and thin, the anterior thickened. The foramen is present.

The *humerus* is different in form from that observed in *L. crassartus*, *L ictericus*, *Clidastes*, *etc.* It is relatively less expanded proximally an especially distally; there is but one deltoid crest, which is proximal an near one extremity of the articular surface, and disappears into the gene

ral plane above the middle of the shaft. The general form is flat, partly due to pressure. The distal extremity is but little convex and displays the terminal muscular insertions but little produced. Near the inferior end there is one external expansion for articulation with the ulna.

The *radius* is lost. The ulna, or a bone which is like that regarded as such in several species described by me, has the extremities in different planes which cross each other obliquely. The proximal is triangular and very wide, too wide for the humeri in their present state. It is also too long, leaving but little space for a radius. The distal extremity is as expanded, but much narrower, and presents too articular surfaces, a large and wide, and a narrow, connected by a wide isthmus. The bone was taken out near a humerus, but not in position.

The pelvic arch, as above remarked, was found perfect, and with all the elements in place, with a femur with the head in relation to the acetabulum. The articular extremities are somewhat depressed and do not precisely fit. The *ilium* is a straight flattened bone, dilated moderately at the articular extremity. It is coarsely rugose striate at both extremities. The *ischium* is a longer bone than the ilium, is more slender, and more expanded at the articular extremity, where it is also thickened. The shaft is curved so as to be sub-horizontal in position ; it shows no trace of union with its mate. The *pubis* is a broader bone, with the axis transverse to that of the body, and sigmoidally curved, first slightly forward then gently backwards. The common suture is about as wide as the proximal extremity. The posterior margin is somewhat thickened ; the anterior is produced into a process directed forwards, which is the homologue of that seen in the *Testudinata*. It is connected with the distal end by a thin concave margin.

The *femur* is rather more slender than the humerus; the distal extremity is about as much dilated, the head less so. The great trochanter is a thick convex ridge with a truncate discoidal articular extremity, which is nearly separated from the head by a groove. Both extremities are moderately convex. The *fibula* is similar to that of other species in its broad, three-quarters discoidal form. Both articular surfaces are strongly convex and are continued on the inner side on the thinned inner border. The external margin is thickened and deeply concave, and without tuberosity. The *tibia* is a more slender element with sub-cylindric shaft and much expanded extremities. The proximal is oval and is continued as a narrow ridge on the inner side, for contact with the corresponding ridge of the fibula. The distal extremity is an equilateral spherical triangle, of which the inner angle is on a different plane from the remainder.

The *phalanges* are slender with cylindric shafts and expanded extremities, which support oval articular surfaces. Those of the two extremities appear to be similar. The distal ones are extremely small and flat, with expanded extremities.

Of *doubtful bones* may be mentioned two with flat expanded distal extremity and thick proximal, bearing an oval articular surface, with an

angulate extremity which terminates in a thin edge. The form is like that of a narrowed radius of *L. ictericus*, but it is much too short for the ulna. As it was found with the scapula, it is probably a portion of the fore limb, and hence may be a metacarpal. A somewhat similar but narrower bone may be metatarsal. A piece which is probably the free *hypopophysis* of the atlas, is a transversely elliptic piece with an oblique smooth articular face at one end. The posterior face rugose, the inferior with a flat truncate process directed downwards and backwards. If correctly identified, its great peculiarity consists in its thinness anteroposteriorly, and the large process.

In comparing this species with the *L. proriger*, its nearest ally, I have already observed the difference in the form of the articular surfaces of the cervical vertebræ, which is in that species vertically oval; the present, transversely so. The comparison is made between posterior cervicals of both, which in *L. dyspelor* are less depressed than the others. As it is possible that the form in the type example of *L. proriger* may be slightly affected by pressure, I compare other points. Thus the palatine bones are more slender anteriorly, and the outer edge descends lowest in a ridge; in *L. proriger* inner is produced downwards as a longitudinal rib. In this species there are eleven teeth; in that one, nine. The quadrate bone of *L. proriger* presents a longer external angle, and more prominent external ridge, with smaller space enclosed by the bases of the greater ala. My statement in a published letter to Professor Lesley, that the ends of the mandibles were acute, thus differing from *L. proriger*, is an error, due to my having mistaken the palatines for the dentaries on a cursory examination in the field. The posterior extremity of these bones in *L. proriger* is unknown.

The only species whose dorsal vertebræ are known to resemble in the stoutness of their form those of *L. dyspelor*, is *L. crassartus*; the manifold differences of the latter will be at once discovered on reading the description already given.

Measurements.

		M.
Atlas length inner articular face		0.065
" " posterior " "		.054
" depth " " "		.037
Axis length at middle of side		.075
" depth anteriorly		.081
" elevation neural spine		.075
" width " " (plane)		.045
" diameter ball	vertical	.07
	horizontal	.07
Cervical " "	vertical	.066
	horizontal	.076
" length		.09
Anterior dorsal, diameter ball	vertical	.065
	horizontal	.087

Measurements.	M.
Anterior dorsal, length below (with ball)	.10
" " " diapophysis	.047
" " depth "	.04
Posterior " length centrum	.097
" " diameter ball { vertical	.076
" " diameter ball { horizontal	.105
" " height neural spine (of another)	.12
Lumbar length centrum	.09
" diameter ball { vertical	.073
" diameter ball { horizontal	.09
" length diapophysis	.096
Caudal (anterior) length centrum	.073
" " depth ball { horizontal	.085
" " depth ball { vertical	.075
" " length diapophysis	.12
" (posterior) " centrum	.067
" " " diapophysis	.10
Caudal (posterior) height neural spine	.087
" " diameter ball { vertical	.08
" " diameter ball { horizontal	.084
Maxillary bone, length	.65
" length basis of two teeth (largest)	.09
Mandible, depth behind cotylus	.11
" length " "	.11
Width nasal septum	.021
Length palatine on tooth line	.38
Depth " at third tooth from front	.039
Quadrate length	.15
" " external angle	.029
" width face from meatus to external ridge	.029
" " area of basis of ala	.04
" " at condyles	.07
Scapula, height (axial)	.12
" width	.183
Coracoid, "	.187
" length	.20
" thickness at cotylus	.027
Humerus, length	.189
" proximal width	.12
" distal "	.127
Ulna, length	.179
" width { proximal	.115
" width { distal	.116
" thickness proximally	.06
Ilium, length	.245
" width { proximal	.039
" width { distal	.178

Ischium, length on curve		.350
" width	proximal	.018
	distal	.087
Pubis, length (straight)		.195
" " to anterior process (axial)		.125
" width	proximal	.085
	distal	.075
Femur, length		.185
" width	proximal	.093
	median	.064
	distal	.130
Fibula, length		.116
" width	proximal	.100
	distal	.118
" proximal thickness		.052
" median width		.08
Tibia, length		.103
" width	proximal	.045
	median	.025
	distal	.052
" thickness	proximal	.042
	distal	.030
Phalange (posterior), length		.08
" terminal "		.015
Estimated length, cranium (five feet)		1.510
" total length		75 feet.

This specimen does not appear to be quite as large as the type, which came from Fort McRae, New Mexico. The diameters of the vertebral centra appear to be larger in proportion to the length of the cranium than in the *Mosasaurus dekayi*, hence probably the body had a greater diameter. In estimating its length, reference is had to the relations in size of the caudal vertebræ of the type of *L. proriger* and to the caudal series of a small *Liodon* found on the bluffs of Butte Creek. The caudal vertebræ are quite similar to those of the former; in the latter, a series of thirty centra exhibit very little diminution in size. On such a basis the length would be about seventy-five feet.

Portions of a second individual of this species or of *L. proriger*, were found on Fox Cañon. They belonged to a larger animal, one equal to the New Mexican first described. Professor Mudge has fragments of still larger specimens.

The principal specimens above described was excavated from a chalk bluff. Fragments of the jaws were seen lying on the slope, and other portions entered the shale. On being followed, a part of the cranium was taken from beneath the roots of a bush, and the vertebræ and limb bones were found further in. The vertebral series extended parallel with the outcrop of the beds, and finally turned into the hill and was followed so far as time would permit. It was abandoned at the anterior caudal vertebræ, for more favorable circumstances, or a more persevering excavator.

The outcrop of the stratum was light yellow. The concealed part of the bed was bluish. Yellow chalk left on the specimens in thin layers became white or nearly so. The yellow and blue strata are definitely related in most localities, the former being the superior, but in others they passed into each other on the same horizon.

Stated Meeting, January 5th, 1872.

Present 14 members.

JOHN C. CRESSON, Vice-President, in the chair.

Letters of acknowledgment were received from Professor Lewis Strohmeyer, Dec. 8th, 1870 (81, 82, Proc. A.P.S.), Boston Public Library, Dec. 19, 1871, R. Saxon Society, Feb. 8, and July 8, 1871 (84, 85, Trans., Vol. XIV., i. ii.), Natural History Society, Bremen, Aug. 29, 1871 (83, 84, 85) Professor Frerichs, Feb. 8, 1871 (83, 84, 85), R. Bavarian Academy, Sept. 18, 1871 (83, 84, 85, XIV., i. ii.), R. Observatory, Munich, Aug. 14, 1871 (83, 84, 85), Imperial Russian P. C. Observatory, March 13, 1871 (62, 73, 74, 78, 81, 82, Trans. Vols. I. to IX., and XIII., iii.), Bordeaux Society of Sciences, Nov. 16, 1871 (82 to 85), R. Academy, Berlin, Aug. 9, 1871 (83, 84, 85, XII. i., XIV. i. ii.), Imperial Observatory, Prag., Aug. 16, 1871 (83, 84, 85, XIV. i. ii.)

Letters of envoy were received from the Chief of U. S. Engineers, Washington, Dec. 21, 1871, and from the Imperial P. C. Observatory, St. Petersburg, Aug. 16, 1871.

Donations for the Library were announced from the publishers of the Flora Batava, and Dr. Schotel, P. C. Observatory, St. Petersburg, Academy and Observatory at Munich, Societies at Bonn and Bordeaux, Geographical Society and School of Mines at Paris, Mr. Stephenson, M. P. Newcastle-on-Tyne, London Nature, R. Astronomical Society, the Natural History Society at Bagota, S. A., the Massachusetts Historical Society, Boston Library, Old and New, Silliman's Journal,

Chief of U. S. Corps of Engineers and Colonel Williamson, the U. S. Coast Survey, Dr. Genth, Dr. Hayden, Mr. Thos. Tennant of San Francisco and Mr. Stephen Olney of Providence, R. I.

Mr. Chase for the Committee on the Paper on Knights' Tours, reported progress.

The death of Robert S. Breckinridge, a member of this Society, at Danville, Ky., on the 26th Dec., 1871, aged 71 years, was announced by the Secretary.

The death of Professor Franz Bopp at Berlin, was announced by letter.

Mr. Eli K. Price read a paper on some Phases of Modern Philosophy, the discussion following which was postponed to the next meeting.

The Chairman of the Finance Committee presented its Annual Report, and, on motion, the appropriations recommended therein for the ensuing year were passed.

Mr. Lesley was nominated Librarian for the ensuing year.

Pending nominations 679 to 688, and new nomination No. 689 were read.

The Reports of the Judges and Clerks of the Annual Election was read, and the following named persons were reported officers for the ensuing year:

President, George B. Wood.

Vice-Presidents, John C. Cresson, Isaac Lea, Frederick Fraley.

Secretaries, Charles B. Trego, E. O. Kendall, John L. Le Conte, J. P. Lesley.

Curators, Joseph Carson, Elias Durand, Hector Tyndale.

Councillors to serve three years, Daniel R. Goodwin, Eli K. Price, W. S. W. Rushenberger, Henry Winsor.

And the meeting was adjourned.

SOME PHASES OF MODERN PHILOSOPHY.

By Eli K. Price.

(*Read before the American Philosophic Society, January 5th,* 1872.)

"I am a brother to dragons, and a companion to owls." So Job wa constrained to say in the hour of his great afflictions : so others now sa induced only by speculative philosophy.

The tendency of much of the modern natural and physical philosoph is to degrade our humanity, and to dispense with the belief of a Creato Delvers in a special field are not content to exhibit what they find for th use of those who are farther advanced and prepared to take a broade survey from a more elevated height; but they theorize and make thei inductions from facts too few and inadequate for the conclusions drawn The result cannot be truth, but error. Theories so built are raised to b quickly thrown down. They are the least fit to survive in the struggle of science.

All carefully observed and true facts philosophy must receive an register for her legitimate uses. But if philosophers be not certain of th truth of facts, and have not all that are requisite for truthful conclusion they violate the fundamental canon of philosophizing: they necessaril land in error, and bring reproach and ridicule upon philosophers an philosophy. Much labor and expense of printing are wasted, while stu dents are misled, science is obstructed, and it is made necessary for th lovers of truth in the next to correct the errors of this generation.

I. The first subject to which I would now ask your attention is that o Spontaneous Generation. Dr. Erasmus Darwin had, at the close of th last century, ascribed to Nature the power of spontaneous generation and thus concludes :

> "Hence, without parent, by spontaneous birth,
> Rise the first specs of animated earth;
> From Nature's womb the plant or insect swims,
> And buds or breathes, with microscopic limbs."
>
> [*The Temple of Nature*].
>
> "Organic life beneath the shoreless waves
> Was born, and nurs'd in Ocean's pearly caves."—[*Ibid*].

But he had the imagination of the poet; and his imagination some times assumed his facts.

There is a present effort to go a step further, and prove that life ca be produced by man from matter, without propagation from other life and if you add to this the theory of evolution, by which all complicate life is derived from first simple forms, we have two theories, which, take together, will account for all life, without a Creator. There are, howeve certain things, like perpetual motion, so contrary to nature, as not to b credible. The fact of spontaneous generation has not yet been satisfac

torily proved; and, it is believed by those best enabled to form a correct opinion, will never be proved. The life produced by the experimenter is, no doubt, but a process of developing seeds or spores, or of hatching eggs, that exist invisibly in the atmosphere, and within the tube used in the experiment, and from which they had not been perfectly expelled. And well it is that life is not, and cannot be, spontaneous, for, if noxious, and no law of reproduction restrained the increase, there could then be no hope of its effectual extermination; but, if depending upon parental production, when you destroy the parents, you destroy the pestiferous succession. This was the basis of the confidence of Pasteur in his successful researches and efforts to find out and destroy the parasite that destroyed the silk-worms in France.

It is also the hope of mankind to escape contagious diseases, that proceed from germs that ever re-produce the same disease, be it small-pox, scarlet fever, or cholera, or other plague, for the spread of which the corrupted air becomes the fitting propagating medium.

If new generation were possible, there would result confusion; it should be bound by no rule if not produced in the course of nature; there could never then be scientific classification into genera and species, and all order and harmony would become impossible. It is a necessary ordination of the Author of nature that generation should come from a living parentage, and that parents should ever produce their like. Such we know to be nature's procedure. Such process must proceed by law, that the progeny shall be like their parents, and of different sexes, and such law and such sure observance of law, imply an intelligent Creator, who never ceases to watch over his creation. Life has been on the earth in countless forms, and in infinite multitudes, through nearly all the geological formations from water deposition, and ever since; but none of that life has been thought to be spontaneous, except in the imagination of the poet, or of the fanciful theorist. All except the first of each kind, for which we infer a Creator, came by generation, from parental germs and ova, as we must believe from observation; or by fission, which but subdivides life and thereby multiplies it. It is, however, now announced in this age of great discoveries that man can produce life where no life was.

Dr. Bastian has made numerous experiments and written a book on "The Modes of Origin of Lowest Organisms," and believes that he has produced them *de novo*, "independently of pre-existing living matter." But his book makes necessary admissions that must go far, if not quite, to destroy his theory. All the living organisms which he produced had been before known as existing in the course of nature, and had been named. They are called *Bacteria*, *Torulæ*, *Vibrones*, *Leptothrix*. But why were these, and but these, produced, unless they had a parentage through germs containing life? Why not something new? Certainly these were not new creations of life, but something re-produced that had before their given law; and it is easier for the scientific mind to believe that the parental germs had not been removed by the experimenter, than that he had witnessed a new production of life. This view is well con-

firmed by this statement of the author: "*Bacteria*, *Torulæ*, or other living things which may have been evolved *de novo*, when so evolved, multiply and reproduce just as freely as organisms that have been derived from parents," p. 3. Now what living thing or creature in all nature ever has propagated, or can propagate its kind, except it has inherited that power from a living parent? From the beginning it has been that the grass, or herb, and fruit tree, "whose seed is in itself," has yielded "fruit after his kind;" and the living creatures have "brought forth abundantly after their kind," and only so have they replenished the earth.

Professor Tyndall's article "Dust and Disease," is commended to the student who would learn how all pervading in the air of London are the seeds of life and of disease. (*Fragments of Science*, 277.)—Stating the result of experiments, he says, "The whole of the visible particles floating in the air of London rooms being thus proved to be of organic origin." (p. 279,) "The air of our London rooms is loaded with this organic dust; nor is the country air free from its presence." (p. 285.) And hence, no doubt, the ova were hatched by Dr. Bastian, or the germs made to grow.

Sir William Thomson in his recent address, as President of the British Association, (Nature, August 3, 1871,) adds his authority to that of the opponents of spontaneous generation. "Science brings a vast mass of inductive evidence against this hypothesis of spontaneous generation, as you have heard from my predecessor, (Professor Huxley,) in the presidential chair. Careful enough scrutiny has, in every case, up to the present day, discovered life as antecedent to life. Dead matter cannot become living without coming under the influence of matter previously alive. This seems to me as sure a teaching of science as the law of gravitation." * * * "I confess to being deeply impressed by the evidence put before us by Professor Huxley, and I am ready to adopt, as an article of scientific faith, true through all space and all time, that life proceeds from life, and nothing but life." Yet he, so true and wise in this induction, did not close that same address without falling into an egregious blunder, eliciting instant dissent and derisive laughter, followed by the universal condemnation of the scientific press. He too would dispense with a Creator, at least, on this planet, for he made the suggestion that the first life came to our world by a falling Aerolite, though it came fused by heat! But that was only to transfer creation to another planet. This suggestion of course committed the learned President to the extremes of the evolutionary theory, was to say that from such life as could be borne hither by an aerolite all other life on earth has come and been developed upwards to man. Of this theory let us next speak, but first pausing to declare our faith that life came only from God, and by Him alone is ever protected and preserved.

II. The theory of evolution as announced, seems to have been carried to an extravagant extreme. Its agencies are chiefly two: natural selection, and sexual selection. The life that is best fitted to endure will live the longest; and the weakest will soonest perish; and that which man takes best care of and most propagates is most likely to live in perpetuity,

while that which he destroys, because hurtful, is most likely to perish; and this is natural selection, and to a limited extent, it is obvious to all. The sexual selection is that which the male or female makes when mating. The latter influence can have no place in the vegetable kingdom, for in it there is no will to exert selection; and there is very little of it, indeed, below man in the animal kingdom; for what female is there in it, unrestrained by man that finds not her sufficing mate, be she beautiful or plain? Nature is not checked in her purpose of multiplication, when free, for want of masculine co-operation, for it superabounds. The seeds of life are always superabundant. All the fanciful writing upon this subject, the motives for the mating of birds and quadrupeds, by the attractions of symmetry and beauty of plumage or color, seem quite unimportant: where all mate sexual selection effects nothing. The real check to increase comes from want of food, severity of climate, disease, and enemies, which spare not symmetry or beauty, and not from any failure to be selected.

Nothing is more certain, however, than that as far as man exercises a dominion, by the culture of plants and breeding of animals, he does greatly increase some in numbers and quality, and he diminishes others. He practices great partially. The flowers and fruits, and vegetables and grains that best please and nourish him, he will most cultivate, and destroy all things that most obstruct their growth. The birds, fowls and animals that are most useful and please him best, he also breeds and greatly multiplies, and he destroys their enemies. The cattle on a thousand hills are justly for its use, because they are bred and fed by himself to do his labor and be his food; and his care and skill make it sure that they shall be the best fitted for his purposes. And this is also called natural selection; although it is the result of man's skill exerted upon nature and the laws that govern nature. Its effect is great, but is not unlimited, and is subject to reversal when man ceases to exert his care and skill.

There is truly a law of nature in propagation, that each species, and each pair of individuals shall produce a progeny like themselves. Man selects the parental pairs of the qualities he desires, and his hopes are seldom disappointed. He repeats the process until he arrives at the highest perfection in view that is attainable; hence our fleet race horses, our strong draught horses; and also our finest breeds of cattle and sheep, selected with a view to their qualities for milking, clip of wool, or beef, or mutton. Thus the wild animals are inestimately improved! And so with these and other purposes, and the large indulgence of a capricious fancy, have pigeons, poultry and dogs been improved, or greatly changed in their varieties, until it is made a question whether such variations have not been carried to the length of making new species. The success of such proceeding has been made the basis of a theory so extreme, that it at once threatens to destroy the classifications of science, and the religious faiths of mankind.

It is, indeed, also true, that the like inheritable qualities exist in the-

human species, and if men and women were as careful in mating, as men are when breeding their horses, cattle, sheep and pigs, to consider whether those they select are well endowed with bodily and mental perfections, the physical and moral qualities of families might also be alike improved; though the unattractive among mankind would still not be disappointed in the opportunity of mating, if they have the means of livelihood or the ability to win it; the want of which constitutes the most serious check to matrimony and the increase of population. But mankind are neither so careful in selecting what shall be the qualities of the father or mother of their children, as farmers are of the pedigree of their stock; nor are men or women so careful of their own training and feeding, and the preservation of their health and beauty by temperance and exercise, so that they are more derelict in duty to themselves than to their animals, and the race has not been improved as it should have been. Yet, it may well be questioned whether the human race is improved in the aggregate by sexual selection, since generally men and women do marry, and since the women who fail to marry from the absence of personal attraction, are probably outnumbered by those whose personal attractions, combined with their moral weakness, causes them to become the victims of "the social evil," of which sterility is one of the retributions. Yet the race, is undergoing a constant physical and moral improvement; but it proceeds from Christian civilization; a civilization that does believe in an ever-living watchful Creator, and that would suffer terrible relapse, if that belief were lost. This is said on the proof of boundless facts.

If we consider the conditions of all life as found in nature, before man began to reduce it to his dominion, and the methods of his procedure and its results, just as the evolutionists have described, we shall be able to value their scientific significance, and to test the truth of the theory raised upon the narrated facts. Darwin in selecting his illustrations says, as to dogs and their various breeds, "that some small part of the difference is due to their having descended from distinct species;" "In regard to sheep and goats I can form no decided opinion." The humped Indian cattle have a different origin from the European cattle, which are supposed "to have had two or three wild progenitors." With respect to horses he says, "I am doubtfully inclined to believe, in opposition to several authors, that all the races belong to the same species." As to fowls, "it appears to me almost certain that all are descendants of the wild Indian fowl." As to ducks and rabbits, "the evidence is clear that they are all descended from the common wild duck and rabbit." "Great as the differences are between the breeds of pigeons, I am fully convinced that the common opinion of naturalists is correct, namely, that all are descended from the rock pigeons."—Darwin on Origin of Species, p. 30 to 35. Now what is the import of this? First, that by nature, or the Cause of nature, when or wherever man has not interfered to modify, the demarcations of species have been well and persistently defined. Through all the geological ages and downward to the time present, the operations of nature, when let alone were and are simple and true, without tendency to variations, or

acting under a power that ever corrected them. The wild progenitors were without variations; in that state new species were not formed by process of variations; nor was there transition by gradual change from a lower to higher species; nor do geology and history afford the proof of such change, and the theory depends upon conjecture asserted against the truth of our observations and just inferences, that nature has always operated as we see her now do in those vast domains of ocean, mountain and forest, that lie beyond the interference of man. With the living ife of the oceans man can do nothing except slightly to diminish the numbers of whales and fishes, and there the processes of nature go on without change; and so has it ever been in the deep recesses of forest and mountains yet unpenetrated by man, or, if the scientific adventurer has penetrated, it has been to leave no trace of his power there. It has been man only that has disturbed the truthful proceedings of nature; modified them for his own benefit.

Again, it is to be considered that all that man has done, he must forever continue to do, otherwise nature will re-assert her dominion, and undo all that man had done to mar, or pervert, or perfect her works; and she will restore them to their pristine simplicity. This we know she is always doing, from abundant observations; she makes hybrids unfruitful; her ban forbids changes that shall endure; the seedsman and gardener ever watch their choice crops, fruits, vegetables and esculents, and must do so, for they know well that nature ever resumes the attempt to "cry back;" that is, to return to that condition from which the skill of man has forced her to meet his own wants, or to please his fancy. Who can reasonably doubt that if man was to cease to be on the earth that his seeds, and esculents, fruits, and all domesticated animals would in process of time, return to their natural conditions? Human care and culture and provisions ceasing, the antecedent causes of nature would again come into exclusive operation; and by her own truthful observance of cause and effect, the ancient condition of vegetable and animal life would be restored as they were on the face of the earth. Without his stores of provision and provender and shelter, a single severe winter would cut his before housed and sheltered vegetables and animals, by frost or starvation, down to about the thirty-seventh degree of latitude; and half the variations that have grown up under the training hand of man might perish at a blow. What man has achieved over living nature may, therefore, be considered as an artificial work of but temporary endurance. Darwin fully admits this when he says, "Natural selection is a power incessantly ready for action, and is as immeasurably superior to man's feeble efforts as the works of nature are superior to art." Ib. p. 70. When let alone she elects to return to her original conditions.

Of the variation produced by selection in breeding and the better care of animals, Darwin says, "the key is man's power of accumulative selection: Nature gives successive variations; man adds them up in certain directions useful to him. In this sense he may be said to have made for himself useful breeds." Origin of Species, 40. But what does nature do

when man does not seize upon the offered variations to make them inheritable, by bringing together two of different sexes with the like variations to become parents of a common like progeny, and afterwards preserving only those which most strongly shew the desired variation? The variation from one parent only would quickly fade out into the normal character. Those having variations, Darwin says, "would during the first and succeeding generations cross with the ordinary form, and then they would almost inevitably lose their abnormal character." Ib. 53. Nature, of herself, does not interpose to seize upon and continue the occasionally occuring variation. She does not select a mate of like variation; nor does she develop it to a higher perfection by training or better feeding, and make it the special centre of a favored propagation. Natural selection, unaided by man, must, therefore be of very limited influence, if any, towards establishing a change, whether to be called a variation or a species; while the change that is wrought by man, would, without his continuing maintenance, revert to its normal condition much more rapidly than it was formed. Again variations left only to nature's care, must be such as give increase of strength, otherwise they will die out from weakness as all monsters do, or breed out to the normal condition. Ib. 90, 108. The varieties of pigeons have been the products of man's care for thousands of years; but not one-half the eggs of the best short-beaked tumbler-pigeons would be hatched without his aid to break the shell. Ib. 38, 90. This shews them degenerate; a pampered and failing aristocracy; who, left to themselves, in a state of nature, would quickly die out.

And what is the result of the selection of nature even when most assisted by man? Has it produced any new species? For more than three thousand years before Christ, and ever since, there have been pigeon fanciers who have taken infinite pains in their breeding. Ib. 38. Darwin says, "the diversity of the breeds is something astonishing." "A score of pigeons might be chosen, which, if shown to an ornithologist, and he were told they were wild birds, would certainly be ranked by him as well defined species." Ib. 34. Yet are they such? Darwin says, "the hybrids or mongrels from all the domestic breeds of pigeons are perfectly fertile. I can state this from my own observations, purposely made, on the most distinct breeds. Now it is difficult, perhaps impossible, to bring forward one case of the hybrid offspring of two animals *clearly distinct*, being themselves perfectly fertile," p. 37. Now, if there were a possibility for nature and man together to create new species, it should have been in the instance of the long and general experiment with pigeons. It has at most amounted to producing varieties, in shape and exterior plumage and appearances, while by the truest test of inter-breeding the nature of the creature is essentially unchanged. It is probable that the truth is the same as to dogs, horses, European cattle and fowls, except as disparity in size has rendered the same test of inter-generation to a large extent, impracticable. Surely, then, that law which the Creator has so emphatically imposed upon His creation, He has not himself vio-

lated, in carrying on all His living creation from simple to higher forms through infinite processes of generation. He who has forbidden the confounding of nearly allied species, cannot be taken to have carried on the processes of generation, in violation of the ban against the confusion of species, and in disregard of all the classifications science has adopted from the study of creation, only the better to describe and understand that creation. On the contrary, it is to be taken that generation has no part in the work of creation; but has only her assigned duty, under regulative laws, to propagate creatures of the same species, of two sexes, to reproduce a progeny like unto themselves. All that we can see and know of creation brings us to such conclusion. To create is one thing, and to propagate in the parental likeness another. The propagator but fulfills an assigned instinct that is essentially imperative, except as man is self-restrained by over-ruling moral considerations. His function is a very limited one. The inception of new life, its gestation and growth, and the measure of that growth are the work of that Higher Life or Being, that is, the Giver of all life, as we must logically infer; for every effect must have its adequate Cause.

The great distinctions of classes, orders, genera and species, as the proofs stand in geology, history, monuments and living nature, have ever remained unchanged and unobliterated; while variations within species, have been permitted for obviously good uses to man. The mules that he breeds do him good service, but mules are not permitted to breed mules. A theory that would permit a varying generation to thwart this grand order of life, and that would traverse all these classes, orders, genera and species by violations of the ban we know to forbid hybrids to breed, we may simply set down as contrary to nature and impossible, and such theory demands the clearest and most indubitable proofs, none of which have been adduced.

The theory is wholly illogical and inherently inconsistent with itself. The whole drift of the theory is to make generation build up all created life, with one or a few exceptions, without a Creator. But why any exception? Only that there shall be a starting point in life; that there shall be an incipient generator in this mighty process. But this earliest life must have had a Creator, and the capacity to generate life through all kinds must have come from a Creator; yet this theory demands none, at the beginning, or in any stage of progression, but it obviously proceeds upon the ground that generation will suffice for all life, and that life needs no Creator. Yet there is an overruling power, without which generation could not proceed, without whom there would be no ban against confusion, and without whom the required difference of sex would not come into being in the requisite proportion. The reasonable inference to be made is, that as a Creator was required for the first life demanded by the Darwinian theory, and for all its processes of generation, and the after preservation of all creatures born, the same Creator would himself create all the creatures that share his protection, in all their various species, and do so as the world was prepared for them, and was of the

temperature and had the food they required. The first creatures had a delegated power of generation; but nothing in nature has shown that they had a mission to carry on creation to higher levels either of physical structure, or moral excellence, or of intellectual power.

The whole theory is built upon chance variations from the normal course of nature, occurring at very long intervals of time. It is, therefore, presumably, not the method by which the Creator has built up creation, from one or a few of simplest forms of life, into all the elaborate classification in which we now behold it. Thus, Darwin says, "Natural selection acts only by taking advantage of slight successive variations; she can never take a sudden leap, but must advance by short and sure, though slow, steps." Ib. 190. "New variations are very slowly formed, for variation is a slow process, and natural selection can do nothing until individual differences or variations occur, and until a place in the natural polity of the country can be better filled by some modification of some one or more of its inhabitants." Ib. 171. We have seen that the help that man can give to promote such variations is very limited, and that what he effects would soon relapse without his continuing maintenance, and remain but a variety, and result in no new species; what else but nature, then, when man is not co-operating, is to "take advantage of the slight successive variations?" And what does she do? If but one parent has the variation it will very soon run out in the generative process. This Mr. Darwin readily admits, and candidly stands corrected by the North British Review, while monster variations seldom live any length of time. Ib. 93. Thus the aberrations of nature are so few and far between, and so soon to disappear, as to afford no adequate ground for the change of any species, much less suffice to produce all the classes, orders, genera, and species, into which science has arranged all living things, from one or a few primary simple types. Nature is, indeed, slow to make enduring changes, but quick to correct her errors. If jostled in her processes, she does not make the imperfect product the basis of her further work to enlarge and perfect her systems of life, that all provided food should have its fitting consumers. Nature is ever truthful and casts aside all her products that have been marred upon her wheel, and uses most those which come most perfect from her hand, and thus her progress is ever steady, or is improvement towards her best standard of each created species, under favoring circumstances; but is degradation where unfavorable, or man violates the law of his well-being. This is confidently said after such general survey as all who are intelligent may make, —all who will lift up their eyes and behold the operations of all living creation, or read the geological records,—not looking too constantly downward with limited vision as wedded to pre-conceived theory.

Darwin admits the dearth of facts to sustain his theory, and enters into explanations why they are not found. He says: "To sum up, I believe that species come to be tolerably well-defined objects, and do not at any one period present an inextricable chaos of varying and intermediate links; first, because new varieties are very slowly formed, for variation is

a slow process, and natural selection can do nothing until favorable individual differences or variations occur." Ib. 171. But if all the classes, orders and species come from one or two original and simple forms of life, there should be everywhere and constantly found intermediate transition links, at different stages of progress towards the new species, and presenting an inextricable chaos. This result is parried by the argument that the process is so slow that it is not seen. The more obvious conclusion would seem to be that this transitional process, or "inextricable chaos," are not seen because never happening. And Darwin candidly states (Ib. 173), "Here, as on other occasions, I lie under a heavy disadvantage, for, out of the many striking cases which I have collected, I can give only one or two instances of transitional habits and structures in closely allied species of the same genus, and diversified habits, either constant or occasional, in the same species. And it seems to me that nothing less than a long list of such cases is sufficient to lessen the difficulty in any particular case like the last." The difficulty was to conceive how an insectiverous quadruped could possibly have been converted into a flying bat. But it should seem this would occasion small difficulty to a theorist who could believe that bats and elephants and man himself, sprang from an ascidian, a radiate, or trilobite, or some other early simple form of life. He, in such case, becomes too carefully scrupulous for his own theory; and he further conscientiously says (p. 198), "we have seen in this chapter how cautious we should be in concluding that the most different habits of life could not graduate into each other; that a bat for instance, could not have been formed by natural selection from an animal which could only glide through the air." Let us observe his wise caution, and doing so we must reject his theory. He gives no proofs that justify his conclusions.

Again, Mr. Darwin is constrained to excuse geology for affording his theory but little support. Too few fossil specimens have been obtained; too many creatures have perished and left no likeness in the rocks. He says, "although geological research has undoubtedly revealed the former existence of many links, bringing numerous forms of life much closer together, it does not yield the infinitely many fine gradations between past and present species required on the theory; and this is the most obvious of the many objections which may be urged against it." Ib. 415. But he does not adequately answer this seemingly well founded objection. He excuses himself by the paucity of facts. Then it may be asked why has the theory been propounded before adequate facts have been gathered? Philosophy reserves the privilege of reprimanding her votaries who built their theories upon insufficient facts; and truth compels her to censure unsparingly. They are not permitted to indulge the ambition of theorizing before they have collected adequate materials for their edifice. Darwin has ranged widely and observantly the realms of nature, and we follow him interestedly; but he seems at fault in making his inductions from the facts he has learned; has built on an inadequate foundation; has made small things important, and overlooked the full

import of the great. If his theory were true, the facts for its support should exist by millions, and by billions. That his researches have not produced the facts he wanted, makes them tell more strongly against him. If all living life, and all that has been, came from first simple forms by slow changes, through all being up to the classes, orders, genera and species that we find in existence, and to have existed through all the geological eras, then intermediate links should have been endlessly abundant, and if but a hundredth part of the fossil kinds had been exhumed, they should necessarily have revealed the wanted evidence; living nature should also have abounded in ample testimony, by endless and inextricable confusion. To reach existing results, the process of change being gradual, the transition creatures should have teemed in myriad forms, other than is now seen in fossil or in life.

But why, if there was such immensity of transition as to account for the astounding changes wrought; why, if such endless variations were started in nature casually, or by chance, without reason or motive; how came nature to act so wisely as to bring order out of confusion and chaos, and on that order to take her stand more firmly than the mountains? In the transitional steps towards all the forms that have existed, of every shape and size from the little Rhizopod, Ascidian, Trilobite or Radiate, at the bottom of the ocean, up to the whale, mastodon and man, during an assumed necessary unimaginable length of time; how was all life so marshaled and placed as science now finds and arranges it, and finds it ever resistant of all change? Intelligence and will, even then, must have governed the proceeding and guided its purpose so that all should live and not work confusion. That Intelligence that could do so much in ruling nature, and could create the earliest life, surely could proceed more directly and without disorder, to create the kinds and species for whom that same Intelligence had provided the land, air, water and food, upon, in and by which they should all live, in congenial habitation. But Darwin never recognizes that Being as essential to his theory: No! the theory makes nature herself a substitute for God. Her forces it was, that from time to time jostled all creatures into slight variations, and then she herself selected the best chance-products of a capricious generation and continued them, and perfected without intending to perfect them, and the life of the weak and monstrous was extinguished, merely because not fittest to survive. If nature has such power over us and ours, and all living, shall we not impersonate and worship her as our deity? Men did do this, in various forms, but it was before science and revelation had dethroned the heathen deities. They are not likely to be restored to the worship of mankind, and thoughtful men generally believe in one supreme God.

And why has there been any limit to classes, orders, genera and species? And why has the growth of each and all creatures had their normal limit? Certainly by some intelligent Power that ruled over what are called the forces of nature. Why cannot the naturalist more frequently elevate his views to recognize an Intelligence, without whom all that he studies, himself included, can have little significance, or philosophy any worthy or

consistent foundation? God's order is the source of all science and philosophy. But Darwin neither acknowledges nor denies the ruling of the Deity; he invokes not His aid in the processes of nature; nor yet does he deify nature, but says this of her: "It is difficult to avoid personifying the word nature; but I mean by nature, only the aggregate action and product of many laws, and by laws the sequence of events as ascertained by us." It is obvious that the effect of the theory is displacement of God from His works and from the mind of the naturalist. But the laws of nature could not exist without nature had a Creator, and law a Law Maker. Darwin admits that the "highest intellects that have ever lived," have believed "there exists a Creator and Ruler," but his theory makes no account of Him. He would make nature Godless.

While Darwin's theory undertakes to rise from a few simple first forms of life to higher and more complicated, he denies any purpose of a designer to perfect his works, or any general tendency in nature to do so. He says, "whatever may be thought of this view, in none of the foregoing cases do the facts, as far as I can judge, afford any evidence of the existence of an innate tendency towards perfectibility or progressive development.' Ib. 132. The variations spring from individuals; but from what cause or with what purpose is not explained. The mass of the species remained unchanged, and so live on through many geological periods. He says, "Geology tells us that some of the lowest forms, as the infusoria and rizopods have remained for an enormous period in nearly their present state." Ib. p. 123. "I believe that many lowly organized forms now exist throughout the world, from various causes. In some cases, variations or individual differences of a favorable nature may never have arisen for natural selection to act on and accumulate. In no case, probably, has time sufficed for the utmost possible amount of development. In some few cases there has been what we must call retrogression of organization." p. 124. All, therefore, has come from chance individual variations. Thus all higher life, man included, has been lifted up, by chance-coming variations, generated in the lowest and lower forms of animal life, without purpose, design, or Designer: though the result is the exalted being man!

I make this statement with due care: He says, as to the mode of transition, "there is no reason to doubt that the swim-bladder has been converted into lungs, or an organ used exclusively for respiration. According to this view it may be inferred that all vertebrate animals with true lungs have descended by ordinary generation from an ancient and unknown prototype, which was furnished with a floating apparatus or swim-bladder." *Ib.* 183. This does not except the vertebrate man. He insists upon placing man in the order Quadrumana; says, "If man had not been his own classifier, he would never have thought of founding a separate order for his own reception." 1 Descent of Man, 183. He further says, "we will now look to man as he exists; and we shall, I think, be able partially to restore during successive periods, but not in due order of time, the structure of our early progenitors. This can be effected by means of the rudiments which man still retains, by the characters which occasionally

make their appearance in him, through reversion, and by the aid of the principles of morphology and embryology. The early progenitors of man were no doubt once covered with hair, both sexes having beards ; their ears were pointed and capable of movement, and their bodies were provided with a tail, having the proper muscles. Their limbs and bodies were also acted on by many muscles which now only occasionally re-appear, but are normally present in the quadrumana." * * "The foot, judging from the condition of the great toe in the fœtus, was then prehensile ; and our progenitors, no doubt, were Arboreal in their habits, frequenting some warm forest clad land. The males were provided with great canine teeth, which served them as formidable weapons." Ib. 198. "In a series of forms graduating insensibly from some ape-like creature to man as he now exists, it would be impossible to fix on any definite point when the term 'man' ought to be used." Ib. 226. That is, when he ceased to be monkey and became man, by physical transformation. Mr. Darwin has not attempted to show us in geology, in history or in life, a man at the point of transition, or to imagine or describe what he could be, or what the essentials to the change ; nor any creature yet in the process of trasformation.

Thus, it is distinctly avowed that man was the result of this theory of evolution, and that his ancestor was an ape ; whose ultimate progenitor was some trivial form of life in the bottom of the ocean. Thus by chance-begotten variations in the process of generation, all the million forms of life, in all their infinite distinctions, have been formed. Thus, through an instinct which no creature but man ever controls or disobeys, all living life has been built up ; nay, all created creatures were created, except some first simple form, which alone it has been necessary for this theory to invoke, that there might be an inceptive speck of life for the beginning of a process of variable generations. But who gave this power to the first life and all later life to propagate such variable generations? Who created the sexes and the organs of generations? Who prepared the germs of life in one sex to be called into being by the other? Who gave the instinctive desire that starts gestation, and made the progeny to share the likeness and qualities of both parents? Who gave the parental instinct of protection of offspring, and who the requisite intelligence for their nurture? It is left fairly to be inferred that a Creator could only make the first simple form, and not the later higher life ; or that life first came and worked on spontaneonsly. How could the creature of inferior instinct by generation create that which evinces the intelligence of the bee, the ant, the beaver and the elephant? The skill and polity of the bee, that made the ancients ascribe to her a spark of the Divine intelligence? Mere physical changes could not account for all these, and yet less for the mind of man. The Intelligence of instinct, and of mind, are not conceivably the product of matter, spontaneously or generatively, but we must ascribe such endowment to Him who could make the ant wiser than the human sluggard, who forfeits his manhood and dignity ; to a Being infinitely superior in intelligence than

the highest intellect. If God did not create all creatures and endow them with the law of their being, why should He have cared for them as we perceive throughout all nature? He who ascribes nothing to God does not answer the question. The questions which our reason inevitably asks give him no trouble. He is tempted to deify nature but owns no Deity.

There are, indeed, common necessities to all life, that would go further to indicate its unity than the "rudiments" searched out. All must live upon the food that the earth, sea and air supply. All must have power of digestion and assimilation, and mostly have hearts, circulations, viscera, tissues, nerves and brains. The vertebrates have also flesh and bones. Now, in all this, there is a greater basis of brotherhood in all animated nature, than in the few small matters upon which the theory in question is built. That life in embryo shall start similarly, is as much to be expected as that the digestion, circulation, secretions and excretions should go on alike. But whatever be the incipient or embryolic resemblance, the mature development is always truthful to the demarcations recognized by the classifications of science. All that have nerves to feel are objects of kindness; but there fraternity ends.

Now, what are the particular things enumerated that declare our ancestors to have been apes? Here is the inventory of them in the author's words: "Some few persons have the power of contracting the superficial muscles on their scalps:" 1 Descent of Man, 19. "One little peculiarity in the external ear:" It is "a little blunt point projecting from the inwardly-folded margin or helix," p. 21. "The nictitating membrane, or third eyelid:" which in man "exists, as is admitted by all anatomists, as a mere rudiment, called the semilunar fold," p. 22–3. Of the sense of smell in man, Darwin says: "No doubt he inherits the power in an enfeebled, and so far rudimentary condition, from some early progenitor, to whom it was highly serviceable and by whom it was continually used," p. 23. "Man differs conspicuously from all the other Primates in being almost naked: but a few short straggling hairs are found over the greater part of the body in the male sex, and fine down on that of the female sex." * * "There can be little doubt that the hairs thus scattered over the body are the rudiments of the uniform hairy coat of the lower animals." p. 24. And he says, "we must consider the woolly covering of the fœtus to be the rudimentary representative of the first permanent coat of hair in those mammals which are born hairy." p. 25. "It appears as if the posterior molar or wisdom-teeth were tending to become rudimentary in the more civilized races of man." p. 25. "With respect to the alimentary canal, I have met with an account of only a single rudiment, namely the vermiform appendage of the cœcum." p. 26. The foramen near the lower end of the humerus is said to be found in one per cent. of modern human skeletons, but much oftener anciently; "one chief cause seems to be that ancient races stand somewhat nearer than modern races in the long line of descent to their remote animal-like progenitors," p. 27–28. "The *Os coccyx* in man, though functionless as

tail, plainly represents this part in other vertebrate animals." p. 28. "It is well known that in the males of all mammals, including man, rudimentary mammæ exist." p. 30, which Mr. Darwin finds it "difficult to explain on the belief of the separate creation of each species." Darwin concludes this enumeration by saying, "The homological construction of the whole frame in the members of the same class is intelligible, if we admit their descent from a common progenitor, together with their subsequent adaptation to diversified conditions. On any other view, the similarity of pattern between the hand of a man or monkey, the foot of a horse, the flipper of a seal, the wing of a bat, etc., is utterly inexplicable." p. 31. And this conclusion may be admitted, if we believe creation had no Creator. But if all creatures had a Creator who endowed them with power to generate their like, but forbade them to generate their unlike, the explanation is clear, and makes that of Mr. Darwin wholly illogical. Was structure so great ever raised on so narrow a foundation! Indeed, this small basis for so tremendous a theory, necessarily brings into question the author's logical powers, and causes thoughtful men to set down much to personal idiosyncracy.

These rudimentary signs of man's relationship to the beast are of small things, indeed, but according to Darwin, of mighty significance: but to common apprehension of less account than the general functions common to mammal life, and the approximation of form between the ape and man; yet, all considered, leaving one a beast and the other an immortal being.

Is it not competent for the Creator to employ similar physical structures and functions in animals, and to give to all the benefits of adaptation to the food they are designed to feed upon, the situations they are to occupy, and the life they are intended to live, without making the one the offspring of the other? He who intended the good of all, would give the good in all to every species, so far as adapted to the welfare of each, and this we can more logically believe than that the man, the monkey, the horse, the seal, bat, &c., have blood relationship through a common ancestor. It is not a welcome belief that whether we eat "fish, flesh or fowl," we are perpetrating a kind of cannibalism, by feeding on distant relatives, though the degree of relationship cannot be traced, even with the help of Mr. Darwin.

And can science dispense with a Creator? The votaries of science may grope through special investigations until they cease to see God in His works. But just so far as they cease to see God as the author of Nature, they seem to cease to understand the logic of creation, in its pervasive features, wisdom and magnificence. Yet this theory of a generated creation, if it could be believed to be true or logical, must still be taken to rest upon a Creator and an upholder of all nature, and of the Universe, while it will not own Him as Author of all kinds of life. But life could not be, nor generation, nor birth, nor growth without His instant sustentation. And shall He not create His creation with all the distinctions of class, order, genera and species as we behold it? He must have created this earth, the sun that warms it, the air, water and food by which all life

must live; and He must have adapted all life to these conditions of nature in which it is placed. He who would deny the Creator in any part of His works must be prepared to do so as to the whole. Whatever be the purpose of the theory its tendency is to teach men not to believe in God or their own souls.

The reader will, if he yield his belief in any degree, reason thus, and say, if I sprang from an almost senseless piece of pristine life; if after my ancestors had arrived to the stage of evolution next preceding man, they were no more than monkeys; then, as I believe, these had no immortal souls so have I not an immortal soul: If I only differ from them by reason of a more perfect physical development, that of itself could give me no claim to an immortal soul. If I sprang from the beast I must die the death of the beast! And this idea would be strengthened by the supposed possibility of a reversal of the process of evolution, under the suspicion of which I would be brought; for Darwin admits that although the ancestral rudiments have become wholly suppressed for want of use, "they are nevertheless liable to occasional reappearance through reversion; and this is a circumstance well worthy of attention." Ib. 18. So, indeed, it appears if man be not yet sure of remaining man; if he may relapse to the ape, or become a new variety and be on the road to become a new species, let those look to the possible consequences who have an extra finger or toe, or whose canines or last molars, or slightly pointed ears, show kindred with the ape or donkey. If their descendants should cease to be man, can they in law inherit a man's estate? If there was such a transition upwards there may as likely be downwards. Who can tell what may be the freaks of nature, if nature be not in the keeping of God?

Mr. Darwin, writing in support of his theory does not show the facts that oppose that theory. He does not show the great differences that exist between the species that he would approximate. This is so both when speaking of the physical structure and the mental powers. When he passes to the admitted great mental and moral disparity between even the savage man and the most intelligent of the inferior animals, he advocates the cause of the latter, by stating what they do with their delegated power of instinct, and that they also exhibit instances of a glimmering reason. He, however, makes no near approximation, and admits the difference to be enormous though the comparison be made with the lowest savage. 1 Ib. 33, 67. The theory is really based but upon the physical structure, otherwise the ape would not have been selected as the progenitor of man, but rather the bee or ant, the beaver, dog or elephant, who are far more sagacious than the monkey.

What do we now behold over the face of the earth? Everywhere there yet abound the animals through which man is imagined to have descended, without having suffered variation or change, though exposed to the like causes supposed to have wrought their fellows into man; and everywhere men, savage or civilized, have been dispersed over the earth, and have so been without any evidence of material physical change, throughout all

the ages of their existence. Surely, to do away with this great fact, and the further fact that all is now proceeding as it did from the dawn of history, written or monumental, we must, in the absence of all other facts, except speculative inferences from very small things, called *rudiments*, conclude that God made man in the image he now bears, physical and mental, except as man has educated himself, as no other creature was ever endowed with the capacity of doing. The great lines of demarcation between the animal that has always followed only his assigned instinct, and the higher being that has always had power to invent and make the forces of nature, and all other animals subservient to his uses,—to invent language, writing, printing, and to indefinitely accumulate knowledge and perfect his own character,—have always existed over the earth, side by side, utterly incapable of fusion, and in extreme contrast, in their most marked characteristics. When we study by the microscope we are not to disregard the great things beheld by the unaided vision. If we see the mote, we must see the beam also.

So far I have but quoted from Darwin in relation to the theory of evolution. His simplicity and candor made it easy to answer him by his own books. A writer in the British Quarterly, for October, 1871, appears to have been assisted by microscopic observations, and says: "Almost every tissue of the newt, frog, toad, and green tree-frog, has individual characteristics of its own, which could be distinguished by one who was thoroughly familiar with the microscopic characters of the texture." "The nerve fibres in every part of the body of the newt, differ in many minute particulars from those of the frog." "In these animals not only do corresponding tissues exhibit peculiarities, but entire organs are totally different." And he points out the differences. "Again, if we take the skin of the four animals mentioned above, although it will be seen that there is a certain general agreement in structure to be recognized, there is not a texture of the skin that is alike in them all," and the differences are pointed out, with the assertion that "these seem to increase in number the more thoroughly and the more minutely the tissues are explored." P. 248-9. If this closer test shall continue to be applied, it probably may yet be believed that "All flesh is not the same flesh; but there if one kind of flesh of men, another flesh of beasts, another of fishes, and another of birds," and that men may safely eat all the others.

Professor Wyville Thomson, in a late lecture in the University of Edinburgh, said: "During the whole period of recorded human observation, not one single instance of the change of one species into another has been detected, and, singular to say, in successive geological formations, although new species are constantly appearing, and there is abundant evidence of progressive change, no single case has as yet been observed of one species passing through a series of inappreciable modifications into another." "Nature," November, 9th, 1871.

And here I would ask to read the forcible statement of our Secretary, Mr. Lesley, who adds his authority and force of logic to that of many eminent naturalists, and, I believe, nearly all the members of this Society

against the Darwinian theory: "If there has been a Darwinian development of animal life upon the planet, then it looks as if it had been carried out along four lines rather than one. Four stand-points of creative energy must have been assumed; four startings out of life must be accounted for; four mysteries, four miracles, four beginnings of creation, to be developed instead of one! But where all is mystery and miracle, additions are hardly noticeable. It becomes Mr. Darwin's business, then, not only to suggest some plausible, rational mode by which one species could gradually or suddenly pass the short interval which separates it from another; his explanation must suffice to bridge the awful chasms which have always kept these four great plans of structure separate, along the lines of their development. He must show us how an animal of radial growth could be developed into one of linear growth. Nay, he must fill up the immense interval between the plant and the animal; and, finally, the chasm between the atom of carbon or hydrogen, and the nucleated cell of albumen or fibrin. He must explain the genius of life itself, before he can make his law of natural selection stand for anything more than a beautifully worded description of the ills that all flesh falls heir to when it is born upon this planet. *How* it is born upon the planet is another matter, and remains unexplained by his hypothesis. We do not get rid of miracles by chasing them back along the ages to the starting point, and concentrating them there. A line of battle is not necessarily vanquished and annihilated when it is rolled up by an attack upon its flank, when there is a reserved force at the other end." "Man's Origin and Destiny," p. 78.

There is, however, one sufficing explanation of the mystery and miracle of life—it is this: that there is a God, and that man has an immortal soul; that this life is but the beginning of an endless being. The good fruits of this faith is an argument of its truth; and man has consciously the sense within him that the life eternal awaits him; and he already here communes with Deity. Such a life and such a soul must have had a Creator infinitely superior to the being created.

It is a decisive objection to the theory of Darwin that it takes account only of physical structure, while the greater disparity between man and all other animate creatures consists in his high moral, intellectual, and religious nature. Lyell cites, to sanction Quatrefages in saying, "that man must form a kingdom by himself, if once we permit his moral and intellectual endowments to have their due weight in classification." "Antiquity of Man," p. 495. "It is by something completely foreign to the mere animal, and belonging exclusively to man, that we must establish a separate kingdom for him," p. 494. Lyell also quotes to adopt the Archbishop of Canterbury, Dr. Sumner, in saying, that the comparison should not be taken from the upright form, nor even from the vague term reason," "but from that power of progressive and improvable reason which is man's peculiar endowment." "Animals are born what they are intended to remain. Nature has bestowed upon them a certain rank, and limited the extent of their capacity by an impassable decree. Man, she

has empowered and obliged to become the artificer of his own rank in the scale of beings by the improvable gift of improvable reason."—Ib. 496–7. And Lyell himself says, p. 498, "We cannot imagine this world to be a place of trial and discipline for any of the inferior animals, nor can any of them derive comfort and happiness from faith in a hereafter. To man alone is given this belief, so consonant to his reason, and so congenial to the religious sentiments implanted by nature in his soul; a doctrine which tends to raise him morally and intellectually in the scale of being, and the fruits of which are, therefore, most opposite in character to those which grow out of error and delusion."

The tendencies of the Authors now reviewed is the most unfriendly to that religious faith on which human welfare essentially depends; yet it is believed that good will result from the divulgence of their theories; but it will be because of their failure; because they will have compelled men to re-examine their faith upon the platform of Science, and thereby confirm their religion received by revelation. They will find in all truth an accord showing its source one; and in the constancy of nature the truthfulness of God. They will find that He who created ever rules His creation and compels it to obey His ordination. They will find that only man was made in likeness unto God, and that he was made to have dominion over all other living creatures. They will perceive that Science can erect no barrier between man and his immortal hopes; that the being of an immortal soul stands elevated above all other animated beings by a distinction that makes him but "a little lower than the angels," and a child of his "Father in Heaven"; a Father who condescends to commune with and be known of His children.

Stated Meeting, January 19, 1872.

Present 20 members.

Vice-President Mr. FRALEY in the chair.

A letter of acknowledgment for Transactions XIV. 1. and Proceedings, 84, 85, was received from the Bureau des Longitudes, dated Observatoire Nationale de Paris, Dec. 1871.

Donations for the Library were received from the Observatories and Royal Academy at Turin, Signor Denza, the Revue Politique, and M. A. P. Hovelaque, of Paris, the London Nature, Dr. Freeke, of Dublin, the Montreal Natural History Society, the editors of Old and New, and the American Chemist, the College of Pharmacy, Franklin Institute and Acad-

emy of Natural Sciences of Philadelphia, the editors of the Medical Journal, News and Library, and Penn Monthly, Mr. Eli K. Price, the Secretary of the U. S. Treasury, the Department of the Interior, the Engineer Department, and the Librarian of Congress.

Mr. B. S. Lyman offered for publication, in the Transactions, a map of the Punjaub Oil region, with explanatory text. On motion, this paper was referred to a committee, consisting of Dr. Genth, Mr. Lesley and Dr. Horn.

Mr. Cope communicated the following paper on a new Testudinate from the chalk of Kansas.

On a new Testudinate from the Chalk of Kansas.

BY E. D. COPE.

(*Read before the American Philosophical Society*, Jan. 19, 1872.)

Associated with the remains of *Clidastes*, and other saurians, and at a distance of two or three hundred yards from the locality of the fossil *Protostega gigas*, were found some vertebræ of a Testudinate reptile, which approaches the type of *Trionyx* and *Chelydra*. It differs so strikingly from both, and from all others yet known, as to require notice, and as the parts preserved (caudal vertebræ) are those most likely to recur in a well-preserved state in strata of this age, I propose to establish a species and genus on them, to aid in the future identification of both strata and animal type.

The vertebræ have elongate centra concave below, and have well-developed diapophyses. A more anterior has transversely oval articular extremities; in another they are much less depressed. The former is the more anterior, being known as such by its larger diapophyses and much smaller articular surfaces for chevron bones; it appears probable, indeed, that this one has been without these appendages. It is, therefore, from the anterior part of the series, from no great distance behind the sacrum. Its position being thus determined, it may be described in detail as follows:

As observed, the centrum is elongate and depressed. The inferior surface at the cup is flat, but is arched upwards, descending again to the rim of the ball. The posterior two-thirds has a median groove, which terminates in a deep notch of the ball, which involves one-third of its vertical diameter, and widens backwards. The ball is transverse oval, and only moderately convex; near its upper margin a small deep pit interrupts its surface, having the appearance of an unusually large ligamentous insertion; its border slightly excavates the margin of the ball. The cup is a transverse oval, wider below. Its inferior and superior margins are so deeply (but openly) emarginate, as to reduce the concavity in the vertical direction very much. From the superior emargina-

tion, a deep groove descends to below the middle, probably for ligamentous insertion. The neural canal is subtrilateral. The neural arch is as usual in this group deeply emarginate in front, and much prolonged behind. The zygapophyses project beyond the ball, and the arch is contracted in front of them. Its upper surface has neither process nor keel, but is rugose for ligamentous and muscular insertion. The diapophyses have a wide base, and are subcylindric.

The surface is delicately reticulate rugose, coarsely rugose on the external faces of the zygapophyses. There are several small pneumatic foramina, the largest being in the bottom of the groove of the lower face.

Another vertebra differs in being rather more slender, and in having an obtuse keel of the neural arch. The pit of the ball is wanting, and the inferior emargination. The chevron articulations are larger, and the groove of the cup occupies the middle, instead of the upper half of the cup.

Measurements.	M.
Length of centrum (greatest)	0.27
Length of centrum } vertical	.01
Length of centrum } horizontal	.017
Elevation top neural arch above floor neural canal	.013
Length of arch on median line above	.02
Width " in front of posterior zygapophyses	.012

A metacarpal or metatarsal-bone, was found near though not with the vertebræ, and probably belongs to the same animal. If metatarsal, it is much stouter than in *Trionyx*, but is more likely to be metacarpal. It is about as long as the vertebræ, centrum and arch together. The proximal end is transversely truncate, compressed L-shaped; the shaft compressed sub-quadrate, the articular extremely hour-glass shaped, with an inferior projection for the insertion of a flexor ligament. Length, M. .034; proximal diameter, .013.

These vertebræ indicate a genus with elongate tail like that of *Chelydra* or probably longer; but they differ from those in that genus, by their procoelian character. An approach to the incised margins is to be found in *Trionyx;* but in those of that genus, where this character appears, the diapophyses are largely developed. The genus is evidently quite distinct from anything known, and we await further remains with interest. The species is much smaller than the *Protostega gigas*, and about equal to the Mississippi *Macrochelys*.

It may be called CYNOCERCUS INCISUS. The remains on which it is established were found by Sergeant Wm. Gardner, of my geological expedition in Kansas, in the yellow chalk near to Butte's Creek, south of Fort Wallace.

The discovery of this species and of the *Protostega* constitutes the first indication of the existence of *Testudinata* in the cretaceous formation of Kansas. The author originally pointed out the existence in it of

Sauropterygia and *Pythonomorpha*, and during the expedition just mentioned, obtained portions of *pterodactyles* and of a crocodilian of the genus *Hyposaurus*. The latter order has not been previously known from that region, and their remains are not common. Prof. Marsh's exploration in the Cretaceous of Kansas added *Pterosauria*, but he has not reported any *Crocodilia*, as I once thought, and incorrectly stated. (Proc. Am. Phil. Soc. 1871, p. 174.) The crocodile may be called *Hyposaurus vebbianus* in recollection of Dr. Wm. E. Webb, of Topeka; it is similar in size to the *H. rogersii* of New Jersey.

An anterior cervical vertebra presents the following characteristics: It is that one in which the parapophysis occupies a position opposite the lower third of the vertical diameter. In it the centrum is stout in form, the articular faces but little concave, the posterior a little more so than the anterior. The anterior is almost regularly hexagonal, the posterior sub-round, a little deeper than wide. The inferior surface possesses a strong obtuse median carina, which disappears in front of the posterior margin. Anteriorly it terminates in a short obtuse hypapophysis. The suture of the neural arch is very coarse. Surface of the bone smooth.

	M.
Length of centrum	.037
Diameter, " anteriorly, vertical	.037
" " " horizontal	.031
" " posteriorly, vertically	.032
" " " horizontally	.031
Length of surface of parapophysis	.015

As compared with the *H. rogersii* of the New Jersey Cretaceous, this vertebra is shorter and stouter, and the extremities less concave; the suture for the neural spine is much coarser.

This crocodile was discovered in a bluish stratum, belonging to the Benton group, or No. 20 of Meek and Hayden, encountered in digging a well in Brookville, Kansas.* This point is considerably east of the exposure of cretaceous rocks seen near forts Hayes and Wallace. It is interesting as the first of the *Crocodilia* found between the Tertiaries of the Rocky Mountains and the Cretaceous of New Jersey.

It was given me by my friend Dr. Wm. E. B. Webb, of Topeka, to whom science is also indebted for the *polycotylus latipinnis*, I have dedicated the species to him.

Dr. Henry Hartshorne read the following paper on Organic Physics.

* This stratum is similar to that in which Dr. Hayden found the fish *Apsopelix sauriformis*, at Bunker Hill.

ON ORGANIC PHYSICS.

By Henry Hartshorne, M. D.

(Read before the American Philosophical Society, Jan. 19, 1872.)

In the title chosen for this paper, there may appear to be something anomalous or contradictory: organic science and physical science being commonly regarded as almost incommunicable departments. But as we have long had, already, organic *chemistry* and animal *mechanics*, the tendencies of opinion, and to some extent the clearly rational interpretation of facts, now favor the re-inclusion of organic natural science under the wide term physics, from which it became long ago separated upon grounds of theory, and as it may still continue to be, for the classifications of convenience.

The proneness for unification, so natural to human intelligence, being methodically sanctioned under what is called the "law of parsimony," the question from period to period in all fields of thought is, how far can we *legitimately get* in our simplifications and unifications? Provisionally, at least, we must mark our steps; as, what is done in these unifications of science is to aim at the "reduction of our complex symbols of thought to the simplest possible" *appropriate* "symbols." When the alchemists thought that they might transmute or reduce all elements to one, they did not succeed. There are now some theorists who would reduce all our ideas of law, order, and causation in nature to the one idea of *continuity*. I believe that they will not succeed, in the end, better than the alchemists. This endeavor is, just now, being made especially in the region of life; and while, as already said, there is enough to sustain fully the proper *inclusion* of vital phenomena along with the other phenomena of nature as *physical*, I hold that there is not enough to establish this *identity* or immediate continuity, in the sense in which it has been asserted by some biologists. Let us address ourselves for a few moments to the elements of this question in its recent aspects.

First: What do we mean by life? What is it that we are to regard as differentiated from, or identified with, the other physical forces of nature? We may drop out at once the old idea, that all actions of a living body, such as digestion, circulation, aeration, and the rest of the *special* functions, are properly called vital; or that these need to have any peculiar or *specific* force, or phase of force, to explain them. Digestion is chemical; circulation, mechanical, and so on. By proper exclusion, then, we come down to this: that only one (perhaps a two-fold) process is truly vital, in the sense that its facts come under the category of no other force of nature, under no other name hitherto known to science, but that of life. And this process is *assimilation*, with type-formation or definite organization as its result: the segregation of matter in a peculiar molecular state, whence comes its assumption of peculiar though rapidly changing forms; the chemical instability of the matter being in direct

correspondence with the mutability of its forms. Life is then a change, a molecular motion; and it needs a name for itself as distinctly as heat motion, electrical, or any other kind of movement. But, is it the direct resultant of those other movements? Is organic evolution simply in the line or plane of the composition of the cosmic forces, gravitation, heat, light, electricity, magnetism, chemism, so as to be the mere outcome of these? I would say, no. And this is a very different thing from denying the *correlation* of the vital and physical forces. They are clearly correlative; but correlation is not indentity. And the question is a deep one, what their exact relation is; it is now one of the cardinal questions in science. Because of the wide variety of its bearings, let us regard their most general aspect first.

Grant, as a postulate, the "conservation of force." Then there follows: 1st, as its corollary, that not only is the total of force in the universe never diminished, but, conversely, this totality is never, by physical causation, *increased*. As apparent exhaustion of force is only its transmutation, so apparent increase of it must also be only transmutation of it.

2d. No *change*, in the nature or direction of any force, can, in accordance with the second law of motion, be either uncaused or self-caused, that is caused by the force itself. Every such change must have a special, sufficient cause. When, then, the laws and tendencies of gravitative, electric, magnetic, chemical and heat and light forces are known, and are found to promote, by preference in all instances, the formation of compounds of *stable* equilibrium, by the union of carbon, hydrogen, oxygen, sulphur, and phosphorus, etc., we must expect this to be *uniformly* the result of their direct action. And, therefore, when we find conspicuously unstable compounds to be formed of those same elements, although in the presence of the same general forces, we ought to conclude the formation of such compounds to be the result of *another* definitely acting force. When the force x has been proved always to act in the line A B, and the force y to act in the line C D, we must be sure that a force acting in the reverse line B A, or D C, or in any line intermediate between B A and D C, cannot be either the force x or the force y, or a force resulting from the composition of X and Y, but must be another force, say z. Assuming the existence of z, we may then endeavor to ascertain its relations to the other forces; and we may also inquire whether there may or may not be still other forces of whose composition it is the resultant. So we ought to conclude that there is a special force, or mode, or line of force, whose action is the assimilation and new construction of organizable, protoplasmic, or bioplasmic matter, because the action so named involves a movement of elements in direct opposition to that produced by the other known forces, as shown especially and invariably by the action of those forces upon the same matter, when death occurs.

I may introduce here a remark upon the chemical part of the discussion; whether, as a matter of *induction*, all *a priori* reasoning apart, we are warranted in saying that organizable matter is and can be never produced

by chemical or any other general cosmic forces. Since Wöhler's first formation of urea from carbonate of ammonia, many years ago, this has been much argued upon. Numbers of organic substances have since been made by Berthelot and others, by more or less nearly direct synthesis. But mark this. With the single exception, *possibly*, though not probably, of neurin (that exception remaining very doubtful yet, especially as the substance so designated as made by synthesis, is reported to be crystalline or crystallizable), all the compounds so formed are not organizable, but what I would call *post-organic* substances, products or educts of retrograde or downward metamorphosis; excreted or secreted,—made in animal or vegetable bodies not by their life-force as such in tissue formation, but by its "composition" or balance *with other forces*, in the retrogressive metamorphosis, the approach toward waste and death. It is not *germinal* but effete *formed* matter, to use the words of Beale. Such, for instance, is even quinia, though not yet made by synthesis. Such may be neurin itself, in the form in which we get it after the death of an animal, since no tissue is more prone to change soon after death than the nervous. In fact, if with Lehmann, Moleschott and Huxley, chemists should assert that life is only a *property* of certain substances, and, as some chemists at least say, that those substances can be made in the laboratory, then we must hold them to the test; and deny the formation of any of those substances themselves, *until they are shown to manifest all their properties, including life.*

Time cannot be allowed in this paper, more than to allude to the present aspect of the closely connected question as to the evidence of experiment, in reference to the origination of minute forms of life. After the controversy (which was very active in the day of Crosse's electrical experiments) had, by elimination, been narrowed down to a chronic debate between Pasteur and Pouchet, we are now surprised by its assuming larger proportions, with Owen, Clark, Hughes Bennett and Bastian, coming out as decided heterogenists, or advocates of abiogenesis. Similar observations and like arguments, however, come up again and again. No better case has ever been made out for heterogeny than by Charlton Bastian in his papers in "Nature," 1870. I need not dwell on the known difficulty of exactness in such experiments, from the first preparation of the apparatus down to the last examination of the results under the microscope: a difficulty, as regards the total exclusion of foreign particles, pronounced by some experts to be insurmountable.

We need only observe here that Bastian's protest against Pasteur's assumption, that the prior weight of improbability is *against* the heterogenic theory, is not warranted; as the burden of proof certainly does rest with the heterogenists. It being perfectly well known that no experience exists of the beginning of life of *larger* forms, however simple, without parentage, we may say that since nothing larger than $\frac{1}{1000}$ of an inch has ever been known to begin life in an entirely inorganic medium, the probability is vast that nothing *smaller* than $\frac{1}{1000}$ of an inch diameter ever does so. While we are not able to say that it is *impossible*, those who assert

it must bring most cogent evidence. And the legitimate *alternative*, in regard to all the *heating* or boiling experiments, is, whether we are to apprehend in them new evidence of the resistance of some low living forms to the usually destructive influence of heat, or to assume the total effect of this, and then conclude that a *de novo* origination of life has really occurred. There are many facts which sustain the choice of the former interpretation; facts, for instance, concerning confervoid vegetation in boiling springs, and such as those observed by G. Pouchet and others, proving the marvellous tenacity of rotiferous animalcular life. Jeffries Wyman's experiments, moreover, seemed to show, that though four hours would not, five hours boiling would, prohibit the appearance of any vitality in the materials under his examination. Frankland and Calvert have since strongly confirmed the same conclusion by their careful experiments. No one, however wedded to heterogeny, can say that we are yet at the end of our knowledge of the limits of vital resistance to physical agencies, including heat. But note further: that putting aside (although Professor Huxley does not) as unjustifiable, the supposition that it was possible for an observer like Bastian to be mistaken as to the really organic character of the very minute filaments and sporules, observed by him in tartrate of ammonia or other solutions, under restricted conditions, we must find in them at least something extraordinarily different from the life which we are accustomed to observe; since a very important part of the whole process was the entire exclusion of air; so that if there was life, it was such only as could exist in distilled water, or *in vacuo*. And here, just as in the controversy upon the essential distinctions between animals and plants, since deoxidation and oxidation, fixation of carbon and its elimination, are directly opposite processes, though we may not yet find their separating line, still the line must *exist somewhere*. And it would be taking for granted a great deal more than any evolutionist has a right to do as yet, to suppose, not only that Bastian had thus manufactured sporules and filaments living in airless tartrate of ammonia, but that all he would need would be some greater variety of conditions and time to evolve from them the whole system of organized nature. Bastian himself has not yet asserted this.

A word more about the above named *opposition* between vital and other cosmic forces. It may be stated thus: According to the nebular theory mostly accepted now as the basis of cosmogony and evolution,—the formation of the worlds of our solar system has been and is attended constantly by the integration of matter and the dissipation of force. I have, in this expression, used Hebert Spencer's words. The spheres in consolidating from diffused nebulous matter *give out* force as heat. But, per contra, *organized beings* integrate matter, and *at the same time accumulate force*. In the language of Professor Barker's able discourse on the Correlation of Vital and Physical Forces, "the food of the plant is matter whose energy is all expended; it is fallen weight. The plant-organism, in a way yet mysterious to us, converts the actual energy of the

sunlight into potential energy within it. The fallen weight is thus raised and energy is thus stored up."

As Dr. Barker adds, the force which is stored up is undeniably physical; but I remark further, that the process *by which* it is *stored* is of another order, and involves a different kind of physical force movement from that by which it is *evolved* and expended.

What more can be made out about this mysterious force of life? Not much as yet; but enough, perhaps, to give encouragement to investigation. Reduced to its simplest element, namely, the cell, or the physiological unit, life is a process of *incretion* and *excretion*. What goes in as food is made into tissue, and (after functioning) comes out as waste. The functioning is secondary to it as *life*, though no doubt in itself primary under the view of purpose. The organic cell converts crystalloid atoms or molecules into colloid molecules. Now what is the difference? not merely in the fact of different degrees of diffusibility, but in the state of the particles; the reason why they are colloidal? May we not conjecture, that it may be owing to a differentiated movement of the *atoms?* Clausius and others have long since given reason for supposing that the particles of all gases are in incessant motion among themselves. May not these atomic movements of the three gases, nitrogen, hydrogen and oxygen, all of which are associated with carbon in bioplasm, be in some manner retained in the integration of the organic cell?

Life-motion is probably not *undulatory*, like light, heat and electrical movement, but rotary or cycloidal. For an analogy, I would allude, somewhat too boldly, to the theory of some astronomers, of the present constitution of Saturn's rings; of multitudinous small masses incessantly in motion among themselves. And the occasion for brevity in this communication must be the excuse for crowding, before I conclude, yet other questionable proposals of analogy; as of the minute microscopic cell, with its inward, and outward currents through undiscoverable pores, with even the incretions and excretions of the sun and its photosphere; whose outward and inward cloud-currents are now being so laboriously studied. Somewhat less remote, certainly, is the suggestion of analogy (*not* identity) of life-actions with effects of some of the other forces of physical nature. I would regard sexual union which (except in mere *dividuation*, such as the life of a tree in its cuttings, or the fissiparous generation of animals) is, until heterogeny or spontaneous generation be proved, the only method of the indefinite continuation of life,—I would regard this sexual union as the true analogue of chemical union. The importance of bi-sexual polarity in organic nature has hardly yet been fully appreciated. Carbon and oxygen uniting give out *heat*, and carbonic acid which escapes. Organisms of two sexes, say the pollen cells and germ cells of a plant combine, and evolve *life*-force, whose products do *not* escape, but *remain* as organizable and organized protoplasmic matter; developing new cells in connection with each other. Yet another analogy with physical force-action may be presented. It is known that phyllotaxis, or

the leaf and branch arrangement of plants, follows a spiral law, arithmetically calculable, and showing a striking correspondence with the order remarked in the successive distances of the planets of our solar system from the sun. But what this phyllotaxis still more readily recalls to us is,—the helix of the electro-magnet; or, rather, of the magneto-electric apparatus. As the opposite polarities of the magnet are to the current of the helix of wire, so may be—of course, we do not say is—sexual bi-polarity to the spiral phyllotaxis. While a spiral tendency or movement cannot be so clearly traced in animals, yet some indices of what we may call *organo-taxis* are not wanting. As opposite leaves are held to represent a double spiral, and whorls two or more, so the bilateral symmetry of vertebrates, articulates and some mollusks, and the whorled form of radiates and cœlenterates, may present or imitate results of a similar polar force.

Another analogy, with which physicists may have more patience, is of a *reverse* kind, with heat. As a spark of fire sets burning an indefinite amount of combustible matter within its influence, so a spark of life vitalizes successively an indefinite amount of viable, organizable material as food. But the difference is, as remarked already, that while the increment of heat-force instigates the continuous *reduction* of less stable conditions of matter to those more stable, the increment of life-force *elevates* materials from stable into unstable substances, with constantly transmuted forms.

To conclude: By no such crude analogies as these can any one imagine that the mystery of life is to be altogether removed. These remarks are presented mainly to suggest and show that inquiry into life-force and its attributes may now legitimately follow methods like in nature those used in studying the other physical forces; and to expand to some extent the germinal thought, that, while life or life-force must yet be always differentiated from the other cosmic forces, it is, like them, a motion, or mode of motion, whose study is a part of physics—organic physics.

I would add that such a view of the correlation of biology with the other physical sciences no more interferes with a theistic and teleological view of creation than does the (now familiar) resolution of many once called vital actions (as digestion, circulation, blood-aëration) into chemical or physical acts, the results of ordinary forces of nature, which are *collocated* in the animal body under the conditions of vitality. To analyze is not to create, or even to show how creation was effected; much less is it to afford a negation of the fact of creation itself. Yet, to analyze is always legitimate in science, so long as it is done accurately, step by step; and this, whether it point to biogenesis or abiogenesis, to the origin of types by interrupted appearances or by evolution.

The discussion of Mr. Price's paper, read at the last meeting, being in order, Mr. Cope made the following remarks:

As the essay read before this Society under the above title, adduces no facts for or against the theory of Evolution not already known, the writer does not propose to criticise it as a whole. His object is to correct some statements of supposed fact, which are germane to the argument of the essay, in which its author has been led astray by the statements of others, or want of familiarity with the subject.

The erroneous statements are the following :

1st. That the gradations of variational and specific form seen among domesticated animals are peculiar to them, not being found among animals in the wild state ; and are therefore due exclusively to the influence of human interference.

2d. That fertile hybrids do not exist in the wild state, and that their existence between domesticated varieties is therefore evidence of their common origin.

3d. That transitions from species to species, as to form and other essentials, occur neither in the present period nor in the succession of geologic strata.

4th. That the examples of intermediate forms, or supposed transitional structures, on which the evolutionists rely, are abnormal or monstrous, or otherwise insufficient for the use made of them.

These are four very natural popular fallacies, and the present seems to be a suitable opportunity for exposing them.

First. That graded varieties and unstable specific forms do not exist outside of domestication, and are due to its influence, etc. To find an unqualified contradiction to this statement, it is only necessary to refer to the diagnostic tables and keys of the best and most honest zoölogists and botanists. It is true that these diagnoses are dry reading to the non-professional, yet they embrace nearly all that is of value in this part of biological science, and must be mastered in some department, before the student is in possession of the means of forming an opinion. The neglect to do this explains why it is that, after all that has been written and said about *protean* species, etc., the subject should be so little understood. The fact is thus : That in every family or larger group of animals and plants, there exists one or more genera in which the species present an aggregation of specific intensity of form ; that is, that species become more and more closely related, and, finally, varieties of single species have to be admitted for the sake of obtaining a systematic diagnosis, which will apply to all the individuals. These varieties are frequently as well marked as the nearly related species, so far as *amount* of difference is concerned, the distinction between the two cases being that in the varieties there is a gradation from one to the other ; in the species, none. Nevertheless, between some of the varieties, transitions may be of rare occurrence, and in the case of the "species," an intermediate individual or two may occasionally be found. Thus it is that differences of the varietal and of the specific kinds are distinguished by degree only, and not in kind, and are therefore the results of the operation of uniform laws. Yet, according

to the old theory, the varieties have a common origin, and the species an independent one. To cite examples of what is asserted, the monograph of the Tenebrionidæ, by Dr. Horn, in the Transactions of this Society, especially the genus *Eleodes*, may be mentioned, or the essay on the genus *Ptychostomus*, in the writer's "Fishes of North Carolina," in the Proceedings of the Society, may be consulted.

It is true that in but few of these cases have the varieties been seen to be bred from common parents, a circumstance entirely owing to the difficulties of observation. The reasoning derived from the relations of differences appears to be conclusive as to their common origin, unless we are prepared to adopt the opposite view that the varieties have originated separately. As these avowedly grade into individual variations, we must at once be led to believe that individuals have been created independently: a manifest absurdity.

But variations in the same brood have been found among wild animals; for example, both the red and gray varieties of the little horned owl (*Scops asio*) have been taken from the same nest.

As further examples of gradation between species and varieties, found in nature, I only have to select those genera most numerous in species and *best studied*. Among Birds: *Corvus*, *Empidonax*, *Buteo*, *Falco*, etc.; Reptiles: *Eutænia*, *Anolis*, *Lycodon*, *Naja*, *Caudisona*, *Elaps*, *Oxyrhopus*, etc.; Batrachia: *Rana*, *Hyla*, *Chorophilus*, *Borborocoetes*, *Amblystoma*, *Spelerpes*, etc.; Fishes: *Ptychostomus*, *Photogenis*, *Plecostomus*, *Amiurus*, *Perca*, and many others.

These *protean* genera are not the majority of those known to naturalists, but are quite numerous. That the variability depends on a peculiar condition of the animals themselves, and not on domestication, excepting in so far as it produces these conditions, is plain not only from the above facts, but from those observed in domestication. It is well known that while pigeons, fowls, cattle, dogs, etc., are very variable or "protean," the pea-fowl (*Pavo*) has maintained its specific characters with great accuracy, during a period of domestication as long as that of the other species named. The same may be said of the Guinea (*Numidia*) and the Turkey (*Meleagris*). These facts show that domestication is only a remote cause of variability.

Second. That hybrids do not occur among wild animals, etc. The affirmative of this question is no more important to the view of evolution than the reverse; nevertheless, if hybridization be regarded by any as evidence of common origin, as the author of "Phases of Modern Philosophy," etc., believes, then some wild species are undoubtedly descended from the same parents. There are a few fertile hybrids in nature, though some animals have been stated to be such without sufficient evidence: for example, the *Colaptes ayresii* (woodpecker) is thought by Professor Baird to be a permanent hybrid between the Eastern *C. ornatus* and Californian *C. mexicanus*, and as it occupied the region between the two (Upper Missouri) there is every reason to believe that such is the case, especially as

it mingles and breeds freely with both the others on the borders of their range.

Third. That transitions from species to species in the present periods have not been observed; nor have they been discovered in passing upwards through strata of the earth's crust.

The all-sufficient answer to this statement is to be found in the imperfection of our system of classification already pointed out. Thus, if we first assume with the anti-developmentalist, that varieties have a common parentage, and species distinct ones, when intermediate forms connecting so-called species are discovered, we must confess ourselves in error, and admit that the forms supposed to have had different origin, really had a common one. Such intermediate forms really establish the connection between species, but the question is begged at once by asserting unity of species, and therefore of origin, so soon as the intermediate form is found; for, as before observed, it is not degree but constancy of distinction, which establishes the species of the zoölogical systems. Transitions between species are constantly discovered in existing animals: when numerous in individuals, the more diverse forms are regarded as "aberrant;" when few, the extremes become "varieties," and it is only necessary to destroy the annectant forms altogether, to leave two or more species. As the whole of a variable species generally has a wide geographical range, the varieties coinciding with sub-areas, the submergence or other change in the intervening surface would destroy connecting forms, and naturally produce isolated species.

Formerly, naturalists sometimes did this in their studies. A zoölogist known to fame, once pointed out to me some troublesome specimens which set his attempts at definition of certain species at defiance. "These," said he, "are the kind that I throw out of the window." Naturalists having abandoned "throwing" puzzling forms "out of the window," the result of more honest study is a belief in evolution by four-fifths of them.

Fourth. That the "variations" or intermediate types pointed to by evolutionists in favor of their positions, are exceptional, abnormal, or too few to be available in demonstration of the origin species in general, etc.

The cases of transition, intermediate forms, or diversity in the brood, observed and cited by naturalists in proof of evolution, are few compared with the numbers of well defined, isolated species, genera, etc., though far more numerous than the author of the article criticised is aware of. Their value in evidence of the nature and origin of the permanent forms, is, it seems to me, conclusive, and to a certain extent, complete. By the inductive process of reasoning we arrive at a knowledge of the unknown from the known, a process which we act upon in our daily affairs, and one which constitutes the key to knowledge. It rests upon the invariability of nature's operations under identical circumstances, and for its application merely demands that analysis and comparison shall fix that the nature of that of which something is unknown, is identical with

that of which something is known. We then with certainty refer that something which is known, as an attribute of that object of which the same quality had been previously unknown.

In application to the question of evolution the following preliminary facts may be assumed :

1. Many species are composed of identical elemental parts which present minor differences.

2. Some of these differences have been seen to arise "spontaneously ;" that is, characters have made their appearance in offspring of parents which did not possess them,—or what is the same thing, are known to exist in individuals whose parentage is identical with others which do not possess them.

3. The gradation of differences of the same elemental parts is one of degree only, and not of kind.

4. Induction : Therefore all such differences have originated by a modification in generation, or have made their appearance without transmission, in descent.

This induction is one of the forms in which the proof for evolution appears, though a more cogent argument is that already presented in Chapter I, of the paper entitled "On the Method of Creation," etc., Proceedings A. P. S., 1871.

The fact that in the majority of species, their origin by descent with modification has not been directly observed, in no wise invalidates the above argument. Unless they present positive evidence against such origin, these are absolutely silent witnesses. He who cites them against evolution commits the error of the native of the Green Isle, who was present at a murder trial : "Although the prosecuting attorney brought three witnesses to swear positively that they saw the murder committed, I could produce *thirty* who swore that they did not see it done !"

Finally, it may be asserted that the Theory of Development is the only theory of creation before the scientific world at the present time. The author of "Some Phases," etc., says, in opposition to it, that *God made* the species, and that their gradual evolution dispenses with His interferences and authorship. Will our author explain to us *how* God made the species independent from the start? No opponent of development has attempted to do this, and until it is done, there can be no theory or doctrine in the field other than that of Evolution. The Evolutionists not only believe with the author criticised, that God made all things, but they attempt to show in the field of biology, *how* He did it.

If they are correct in their interpretation of the facts, there can be, and is, no interference between their views and the purest morality, and the most faithful religion.

Other members took part in the discussion.

On motion, Mr. Lesley was elected Librarian for the ensuing year.

On motion, the nomination of Standing Committees being in order, those of the preceding year were continued.

On motion, the reading of the Catalogue of Members was dispensed with.

Pending nominations Nos. 679, 689, and new nominations 690, 691 were read.

Nominations Nos. 678 to 688 were spoken to by Nominors and ballotted for; and on a scrutiny of the ballot boxes, by the presiding officer, the following gentlemen were declared duly elected members of the Society:

Prof. W. C. Kerr, State Geologist of N. Car., Raleigh, N. C.

Mr. La Motte Dupont de Nemours, Wilmington, Del.

Prof. William P. Trowbridge, of Yale College, New Haven, Conn.

Dr. William Elder, of Philadelphia.

Francis Bowyer Miller, Esq., of the Royal Branch Mint at Melbourne, Aus.

Mr. Guillaume Lambert, Professor of Chemistry in the University of Louvain, Belgium.

Mr. Persifor Frazer, Jr., Assistant Prof. Chemistry, University of Pennsylvania, Philadelphia.

Mr. George W. Hough, Director of the Dudley Observatory, Albany.

Mr. William A. Stokes, of Philadelphia.

Mr. Edwin J. Houston, Professor in the High School and Franklin Institute, Philadelphia.

And the Society was adjourned.

Stated Meeting, February 2d, 1872.

Present, fifteen members.

Vice-President, Mr. Fraley, in the Chair.

New members:—Mr. Stokes, Dr. Elder and Prof. Persifor Frazer, Jr., were introduced to the presiding officer and took their seats.

Letters accepting membership were received from Prof.

Wm. C. Kerr, dated Raleigh, N. C., January 29th; Prof. Edwin J. Houston, dated 3603 Chestnut street, Philadelphia, January 30th; Prof. Persifor Frazer, Jr., dated 137 S. Fifth street, Philadelphia, January 28th; and Mr. Wm. A. Stokes, dated 2026 Delancey Place, Philadelphia, Jan. 25th, 1872.

A letter of envoi was received from the Fondation Teyler.

Letters enclosing the draft of a memorial to Congress, for an appropriation for observing the transit of Venus, were received from Rear-Admiral Sands, dated U. S. Naval Observatory, Washington, D. C., Jan. 18th, 1872, and Jan. 30th, 1872.

On motion of Dr. Ruschenberger, a committee, consisting of Dr. Ruschenberger, Prof. J. F. Frazer and Mr. Marsh, was appointed to consider the subject of preparing a memorial to Congress for an appropriation for observing the transit of Venus, in accordance with the recommendation of Rear-Admiral Sands.

A portrait of D'Alembert, by Rembrandt Peale, was presented to the Society by Mr. Joseph Harrison, of Philadelphia, who purchased it at the sale of the Peale Collection some years ago. On motion, the Secretaries were instructed to tender the thanks of the Society to the donor.

The Secretaries laid on the table for the examination of the members the 87th number of the Proceedings of the Society, just published.

Donations for the Library were received from the Belgian Academy, the Revue Politique; Nature; the Canadian Naturalist; Salem Institute; Old and New; Silliman's Journal; Journal of Pharmacy; Franklin Institute; Academy of Natural Sciences, Philadelphia; the Chief of U. S. Engineers; the Smithsonian Institute; the New York Anthropological Society, and Senator Sumner.

The Anthropological Institute of New York; the Voigtländsche Verein für Naturkunde, Reichenbach a-V.; the Zolog-Mineral. Verein, Regensburg; and the Verein für Vaterländ: Naturkunde, Stuttgart, were, on motion, placed on the list of corresponding Societies, to receive the Proceedings.

The death of Mr. Edward Miller, a member of the Society,

on the 1st instant, at West Philadelphia, in the 62d year of his age, was announced by Mr. Fraley, with appropriate remarks. On motion, Mr. Solomon W. Roberts was appointed to prepare an obituary notice of the deceased.

The Committee to which was referred the paper and map of Mr. Lyman, on the Punjaub Oil Region, reported in favor of its publication in the Transactions.

Mr. Lyman exhibited a large map of the region between Rawul Pindee and the Salt Range, published by the British Government, and described the zoological structure and mineralogy of the country.

Dr. G. B. Wood, referring to his previous communications of the use of potash salts in agriculture, made some additional remarks on that subject.

Professor Cope offered for publication in the Proceedings a paper on "The Families of Fishes of the Cretaceous Formation of Kansas."

Pending nominations Nos. 689, 690 and 691 were read, and the meeting was adjourned.

Influence of Fresh Wood-Ashes on the Growth of Wheat, Potatoes, &c.

By Dr. George B. Wood.

(*Read before the American Philosophical Society, February 2d*, 1872.)

In a communication made to the Society at their meeting of January 6th, 1871, in relation to the efficiency of fresh wood-ashes in the revival of prematurely failing fruit-trees, I took occasion to suggest that, upon the same principles, they might prove equally efficacious in preventing the failure or deficiency of the wheat crop, so common of late in the old settled parts of our country. The opinion was based on the large proportion of potassa found in the ashes of the wheat plant, when burned in the growing state; exceeding as it does twenty times that of common unleached ashes. Wheat, therefore, requires a very large relative proportion of the alkali for its growth, more than can be derived from an exhausted soil, even when aided by manure, which, though it contains a considerable quantity of the salts of potassa, cannot yield enough to the growing wheat to insure a large crop. But this was mere speculation, and the question could be decided only by experiment. Accordingly, as stated in my last communication, I selected an acre of ground, and dividing it into three parts, treated one with ashes alone, another with ashes

and swamp-muck conjointly, and the third with muck alone; the muck being applied as ordinary manure, and the ashes sprinkled upon the ploughed ground at the same time with the sowing of the wheat, and then harrowed in along with it. This was done early in the autumn of 1870. Even during the same season, the eye could readily perceive the more luxuriant growth of the wheat where supplied with ashes, and a line of division between this portion of the lot, and that simply manured, was very obvious. But the point in question could not be decided until harvest time next year. Unfortunately, circumstances prevented me from being present at that time, and I had to depend for the result upon the report of my agent, in whom, however, I have great confidence. He reported that he gathered the wheat from small and perfectly equal portions of the two divisions, of which one had, and the other had not been ashed; finding no such difference between the two ashed portions as to render it worth while to distinguish them. On separating and measuring the wheat, he found that the quantity from the ground where the ashes were used was about double that from the part which had been supplied with muck alone, and, in relation to general productiveness, was in the proportion of about 27 bushels to the acre, far exceeding the ordinary crop, which, though under peculiarly favorable circumstances, it may sometimes equal 20 bushels to the acre, does not often, according to my experience and observation, exceed 12 or 15 bushels. It should be mentioned that the ground on which the experiment was made was of nearly equal quality throughout, and very poor.

But I have to mention a fact connected with these proceedings, which goes still further than anything yet said to prove the efficacy of potash in the wheat culture. The common poke is a plant abounding in the salts of potassa, and, therefore, selects for its own growth new and rich soils, which have not yet been exhausted by cultivation. Upon the heaps of swamp muck, thrown up on the borders of cranberry meadows in the process of their preparation, the poke springs up very rapidly and copiously, so as in a short time to completely cover the heaps; and the eye at once recognizes a muck bed by this luxuriant covering. By gathering and burning this copious crop, we obtained a quantity of ashes remarkably rich in potassa, containing at least 45 parts of the alkali in 1000 of the ashes, and therefore very nearly equaling in this respect the growing wheat. To test the quality of some ashes thus obtained, we substituted it for the common wood ashes in a small space of that division of the ground which was treated with this material. Within this small space the wheat grew most luxuriantly, with stems higher and stronger, and heads longer and fuller than those of the plant in other parts of the lot; and, when the crop was gathered, the produce was found to be in the proportion of thirty-eight bushels to the acre, exceeding by more than one-third that obtained under ordinary wood-ashes. As the proportion of the alkali in the two kinds of ashes used was the only point in which they materially differed, the necessary inference is that the difference in the amount of product was owing exclusively to

the much greater proportion of potassa in the poke-ashes, which exceeded by more than 20 times that of the wood-ashes; and further, that all the effects of ashes in promoting the growth of wheat are ascribable to the alkali contained in them.

These experiments were made on too small a scale, and with too little precision in quantity and measurement, to authorize any very exact conclusion as to the effect of ashes upon growing wheat; but they are sufficient, I think, to prove that the effect is very great, and that the farmer may have recourse, with great hopes of advantage, to this agent, if attainable at a suitable price. If the plan be generally adopted, the ashes would soon fail; but I have no doubt that commercial potash might be substituted for them, with at least equal effect; one pound of it being equivalent, I presume, to about a bushel of the best wood-ashes. Should the supply of commercial potash fail, recourse may be had to the alkali as now procured from mineral sources, which will probably prove inexhaustible.

A few remarks on the mode of using the ashes, or their alkaline substitute, for the promotion of the wheat crop, may be acceptable to those who, without previous experience, may be disposed to try the measure.

When leached ashes have been used as a dressing for wheat, for which experience has long showed that they are among the best fertilizers, they have been applied in the same manner as ordinary manure; being first spread upon the surface, and then turned under by ploughing. This method is correct; because the very small proportion of potassa contained in leached ashes is in the form of the insoluble silicate, which cannot be dissolved or carried away by the rains, but which is probably slowly converted, as wanted, into the soluble carbonate by the influence of the rootlets, which then absorb it. The unleached ashes, containing the alkali in a soluble state, cannot be treated in the same manner; as their alkali would be dissolved by the rain, and carried away, in great measure beyond the reach of the roots. I have, therefore, caused the ashes to be sprinkled or otherwise spread, as equally as possible, over the surface of the ploughed ground at the same time that the wheat is sowed, and the two then to be harrowed in together. The grain is thus brought into contact with the ashes, and, when the alkali is dissolved out, is ready to appropriate it to its own development. But as all the unappropriated alkali is probably dissolved out, and carried away by the winter rains, I direct that, in the early spring, another coating of ashes should be sprinkled over the young wheat, so as to yield it a supply of the alkali during the growing period.

The same plan, essentially, should be followed in the use of commercial potash. Being extremely soluble, it should first be dissolved in water, and the solution then sprinkled over the ploughed ground at the sowing of the wheat, and again in the early spring upon the crop as it is beginning to grow.

As to the precise quantity of ashes or of commercial potash to be

used, in proportion to the extent of ground, I am not prepared to say; but I believe that I have employed from 25 to 50 bushels of the fresh wood-ashes to the acre. I have no doubt, however, that this quantity might be greatly exceeded, not only safely but with advantage; as shown by the effects, before mentioned, of the poke ashes, which must have been equivalent in alkaline strength to at least 20 times the quantity of common unleached ashes.

Every farmer, in whose family the ashes are lixiviated for the preparation of soft soap, has it in his power to make a little experiment, the result of which may determine his future course. Let him beg from the women a bucket full of lye, and, after sowing his wheat in the autumn, let him, by means of a tin watering can with perforated spout, sprinkle the liquid equally over a small portion of the field, and repeat the process upon the same plot of ground when the wheat begins to resume its growth in the spring. If he find the product of the small plot thus treated greatly in excess of the average of the field, he may gain confidence to proceed on a larger scale, and thus perhaps, materially advance his income.

Within about a year, my attention has been attracted to the potato crop, with reference to the use of fresh ashes in its cultivation, and I have little doubt that the same treatment may be applied to this as to the wheat, with at least equal advantage. On consulting the chemical authorities, I found that the stems and leaves of the common Irish potato are even richer than the wheat plant in the salts of potassa; their ashes containing 55 parts of potassa in the 1000, while the proportion of wheat is only 47. Now the potato crop has of late years, in my neighborhood, been much more uncertain than formerly; even, I think, independently of the disease which has from time to time made so much havoc with this crop. It is highly probable that the cause, as in the case of fruit trees, may be a deficiency in the supply of potassa, and it is not impossible that the disease which is believed to have its origin in a microscopic fungus, may, like the worm at the root of the peach, depend upon the deprivation of the alkali, which may be necessary to the protection of the plant against these low parasites. To determine this point, as far as a single observation could do so, I had a quantity of potatoes planted last spring in rows, a certain number of which were supplied with fresh ashes in the hills, while the remainder were treated only with manure. In the rows in which ashes were used, the plant grew much more vigorously than in the others, and the product in potatoes was, I believe, about double; though I cannot recall the precise figure, in this case.

I have under way, this season, an experiment on the application of fresh ashes to the wheat crop on a much larger scale than the first; and my intention is to pursue a similar plan with the potato, at the time of planting in the spring. Should I be spared to see the results of these trials, I hope to be able to present a statement about them to the Society. Should the opportunity offer, I intend also to try how facts will support my

supposition, in relation to the use of common potash as a substitute for ashes.

I cannot close this communication without referring to the original subject of the revival of prematurely failing peach trees. I have continued to apply ashes in the same manner as at first, in the autumn or spring, or both, to the different kinds of fruit trees; and, I believe, with uniformly favorable results. The peach orchard, which, four years ago, appeared to be in a dying state, and had for several seasons ceased to bear fruit, is now in a vigorous state, and last summer yielded a copious crop. The old apple orchard, which was so wonderfully revived two years since, continues apparently, except in the case of a few trees dying from old age, to hold all that it had gained, though we lost the crop last year through the destruction of the blossoms by a late frost. The pears and quinces of which the blossoming period differed from that of the apple, so that they escaped the frost, were full of fruit; and I was particularly struck with one old quince tree, which, before the use of ashes had borne scanty crops of a small, imperfect, knotty fruit, but, last year, under the influence of ashes, was loaded with smooth and well formed quinces.

I have not yet been able to form any positive conclusion in relation to the protective effect of fresh ashes against the curculio in the plum tree; but I am prosecuting some inquiries in this direction, and hope before long to be able to solve the question either favorably or unfavorably. I must confess, however, that I am by no means sanguine of the former result.

ON THE FAMILIES OF FISHES OF THE CRETACEOUS FORMATION OF KANSAS.

By E. D. Cope.

(*Read before the American Philosophical Society, January 5th,* 1872.)

SAURODONTIDÆ.

Cope. Proc. Amer. Philos. Soc., 1870, p. 529. Hayden's Survey, Wyoming, etc., 1871, p. 414.

A considerable accession of material belonging to several species of this family, furnishes important additions to our knowledge of their structure, and enables me to determine their affinities with more precision than heretofore. The results are of value to the student of comparative anatomy, and also to the palæontologist, as they appear to have been the predominant type of marine fishes, during the cretaceous period, in the North American seas, and to have been abundant in those of Europe.

The characters already assigned to the family are confirmed by the new species discovered, and many additional ones added, as follows:

The cranial structure cannot be fully made out, but the following points may be regarded as ascertained: The *brain case* is not continued between the orbits, and the basis cranii is double and with the muscular tube

open. A large lateral cavity is enclosed by the proötic, the pterotic, the epiotic, etc. There are no exoccipital condyles, and that of the basioccipital is a conic cup. The pterotic and postfrontal are well developed. The ethmoid is well developed and slightly narrowed at its anterior extremity. The parasphenoid is narrowed and elongate; the vomer is continuous with it and is slightly expanded and then contracted at the anterior extremity: neither it nor the parasphenoid support teeth in any of the known genera.

The premaxillary bones are short, and form but a small portion of the upper jaw. The maxillary is elongate and simple. The hyomandibular is rather narrow and does not present an elongate peduncle for the operculum. The symplectic is well developed, entering far into the inferior quadrate. The latter is a broad bone, largely in contact with the metapterygoid, which is itself a thin plate, not probably attaining the pterotic. The superior branchihyals are short rods.

The relations of the supraoccipital, parietals, frontals, etc., cannot yet be satisfactorily made out, owing to the obscurity of the sutures. Nevertheless the following points may be regarded as probably reliable. The frontals have a rather broad union with the ethmoid, and are separated by suture throughout their length. They do not extend much posterior to the orbits and are succeeded by a rather narrow pair of bones which extend to above the *foramen magnum*. These are not united by suture, but present thickened smooth edges to each other, and appear therefore to have been separated by a fontanelle. Each is separated by serrate suture, from a broad lateral bone which is perhaps the pterotic, and certainly includes that element, as it supports the hyomandibular. It is not easy to determine what relation the median bones bear to the supraoccipital, but the structure looks a good deal like that characterizing the *Siluridæ*, or, considering the large pterotics, like the *Mormyridæ* plus the fontanelle. The shorter form of the pterotic in the *Characinidæ* and the *Catostomidæ* causes considerable difference in their appearance. There is no indication of fontanelle between the frontals in *Portheus*.

Portions of the scapulæ of *Portheus molossus* and other species, are preserved. They have very stout articular surfaces, and although not complete, have enclosed, more or less, a very large fontanelle. The superior surface is the larger, and is followed below by two others, the upper subvertical and small, the lower larger and transverse. These are surfaces supporting two basilar elements of the pectoral fin. There were perhaps three basilars, but the base of the coracoid displays no surface for articulation of a third. The suture with the coracoid crosses immediately below the lower condyloid surfaces, and passes just below the scapular fontanelle, leaving in the specimens a fractured surface which probably supported a præcoracoid. There are two fractured bases of the coracoid, which probably unite below, enclosing a foramen. On the scapulo-coracoid suture just within the space between the two inferior condyles is a smooth hemispherical pit of considerable size. Just in front of it is another of crescentic form.

A partially complete circle of bones convex on one side, concave on the other, was found with the remains of two species of *Portheus* and one of *Ichthyodectes*. They look like a *sclerotic ossification*, and as though moulded on a globe. They are not segmented as in Reptilian sclerotic ossifications, nor do they seem to have been completed circles.

The *femoral bones*, or those supporting the ventral fins are preserved in *Ichthyodectes anaides* and a *Portheus*. They are closely united posteriorly, the inner margins gradually approximating to the union, which is accomplished by the application of the subcylindric posterior part of the bones. In *Portheus* they are united by a coarse suture. There are no posterior processes, but the anterior are long and slender. Each is divided, the inner portion being rod-like; the exterior plate-like. The outer is probably the shorter; exteriorly it rises into an obtuse ridge on the lower side, and the plate then expands backwards as well as outwards nearly enclosing a large sinus with the base of support of the fin. The fin-supporting surface is sub-round, with two exterior and one interior articular surfaces, and a projection in the middle, which has one or two articular faces of smaller size. The base of the anterior projections is rather broader in *Ichthyodectes* than in *Portheus*.

Three kinds of *spine-like rays* or supports of the fins have been found in connection with remains of species of this family, and the proper reference to their positions and species is as yet in some degree uncertain. First. The elegantly segmented compound rays originally referred to *Ptychodus* by Agassiz, and described by me under the species *Saurocephalus thaumas*, appear to be referable to the genus *Portheus*, and to be supports of the caudal fin.* Secondly. Spines composed of unsegmented rays closely united edge to edge, and arranged like the fulcra at the base of the external rays of the caudal fin of recent fishes. That is, the first very short; those succeeding, increasing very regularly in length to the last, which forms the apex of the spine. The obliquely truncated extremities of these rods form a continuous sharp edge, which is coated with enamel, and may be straight, or interrupted with low knobs. The former kind belongs probably to *Portheus* and the latter to *Ichthyodectes*. It is nearly related in character to the spines of *Edestes*, the enamel coated knobs of *Ichthyodectes* rising into veritable teeth in the carboniferous genus. These spines are unsymmetrical, and belong either to the pectoral or ventral fins. To which they should be referred, it is not now easy to decide. The living allies of the *Saurodontidæ* do not possess ventral spines, nor do they exist in Physostomous fishes. In the *Siluroids*, the pectoral fins are supported by strong spines, which remotely resemble the present ones in their compound character.

Third. There are numerous flat, more or less curved, spines or rays, of small diameter compared with the length. One surface is covered with a thin, generally striate-grooved layer of enamel, and one edge is trenchant. One side of this edge is more or less obtusely rugose, or thickened.

* See Hayden's Report, *l. c.*, p. 423, where this view is held.

These rays thin out to the extremity, which in some cases at least is not contracted. These rays are composed of appressed halves, are unsymmetrical with basal hook, and belong no doubt to paired fins. If those already described are pectoral, these are ventral, and *vice versa*. A series of them found together had much the form of either of these fins, while their number would identify them with the ventral. In the rays found together, the first only had a trenchant outer margin, while several had a rabbet along one side of the posterior margin. I have already described such a spine as pertaining to the pectoral fin of *Ichthyodectes prognathus*.

The *vertebræ* in all the species certainly assignable to this group, are where known, deeply two-grooved on each side, besides the pits for the insertion of neurapophyses and pleurapophyses, except in the cervical region where the lateral grooves are wanting. There are no diapophyses. The caudal vertebræ are rather numerous but not so much so as in *Amia*, nor are they so much recurved as in that genus.

Until the structure of the posterior cranial roof and of the scapular arch are fully made out, it is premature to state precisely the affinities of this family. So far as known they are *Isospondyli* with some characters of the *Salmonidæ*, and some of other significance. The large foramen behind the proötic bone is more *Clupeoid* in character. The femoral bones are more like those of the *Plectospondyli*, dividing in a measure characters of the *Cyprinidæ* with those of the *Mormyridæ*. The vertebræ are Clupeoid, while the mode of implantation of teeth is peculiar.

SYNOPSIS OF GENERA.

I. Jaws without foramina on the inner face of the alveolar margin.

Teeth of unequal lengths in the maxillary and dentary bones..*Portheus*.

Teeth of unequal lengths, cylindric....................*Ichthyodectes*.

II. A series of foramina on inner side of alveolar wall.

Teeth with sub-cylindric crowns..........................*Saurodon*.

Teeth with short compressed crowns....................*Saurocephalus*.

There are some other forms to be referred to this family, whose characters are not yet fully determined. Thus *Hypsodon Agass.*, from the European chalk is related to the two genera first named above, but as left by its author in the Poissons Fossiles, includes apparently two generic forms. The first figured and described, has the mandibular teeth of equal length. In the second they are unequal, as in *Portheus*, to which genus this specimen ought, perhaps, to be referred. Both are Physostomous fishes, and not related to the *Sphyrænidæ*, where authors have generally placed them. Retaining the name *Hypsodon* for the genus with equal mandibular teeth, its relations to *Ichthyodectes* remain to be determined by further study of the *H. lewesiensis*.

A species of *Ichthyodectes*, from the chalk of Sussex, England, is figured but not described, by Dixon, in the Geology of Sussex.

A number of forms, erroneously referred by Agassiz and Dixon, to the genus *Saurocephalus*, have been referred by Leidy to a genus he calls

Protosphyræna,* with two species, *P. ferox* and *P. striata*. The latter much resembles a *Saurocephalus*, having equal teeth; while the former probably includes several species, and possibly genera. The teeth first referred to it resemble those of *P. striata*, while others resemble those of *Portheus*. An examination of the figures of the mandibles of the last in Dixon's work, show that the large and small teeth occupy different areas, separated by grooves in a manner quite distinct from anything seen in *Portheus*; but, should it prove identical, it can scarcely be regarded as typical of *Protosphyræna*, which name, moreover, has never been accompanied by the necessary description.

Dr. Leidy applied the name of *Xiphactinus* to a genus indicated by a spine, in some degree like those regarded above as ventrals of *Saurodontidæ*. It is quite distinct from those assigned to *Portheus* and *Ichthyodectes*, and may belong to *Saurocephalus*, as already suggested, or to another genus.

PORTHEUS. Cope.

(*Proceed. Amer. Philos. Soc.*, 1871, p. 173.)

Teeth subcylindric, without serrate cutting edges, occupying the premaxillary, maxillary and dentary bones. Sizes irregular, the premaxillary, medium maxillary and anterior dentary teeth much enlarged. No foramina on inner face of jaws. Teeth on the premaxillary reduced in number. Opercular and preopercular bones very thin. Cranial bones not sculptured.

The fishes of this genus were rapacious, and, so far as known, of large size. They constitute the most formidable type of Physostomous fishes known. Three species are known to the writer, one from teeth only, from the Miocene of North Carolina, but not certainly known to be an intrusive cretaceous fossil; and two from Kansas. The latter are represented by more or less numerous fragments of eleven individuals, three of which possess large portions of the cranium, one almost entirely complete. Two of the remainder embrace jaws, and one a large part of the vertebral column, with segmented rays. In one, these rays were found with the cutting compound ray above described; while the simple flat ventral rays occur with several specimens. In none have any traces of symmetrical spinous rays been found, nor strong interneurals capable of supporting such. In none of the more perfect specimens with crania have the segmented always been found, but the fossil of *P. thaumas*, where they occur, is represented by a vertebral column and its appendages, which do not differ appreciably from those of *P. molossus*.

In the *cranium* of this genus, there is a well-marked supraorbital rim. Each opisthotic forms a prominent angle, directed posteriorly on each side of the exoccipital. The parasphenoid is a stout and narrow bone, deeply emarginate behind, for the passage of the muscular canal. It has a transverse expansion in front of the base of the proötic, which rests on a backward continuation of the same. This expansion is pierced behind

* Trans. Amer. Philos. Soc., 1856.

by two round foramina. The shaft is abruptly contracted in front of the expansion, and is trigonal in section. The prefontal extends downwards and forwards, and carries inferior and anterior articular faces; the latter vertically transverse. The postero-inferior portion of the ethmoid bears on its posterior extremity a concave articular face, which opposes that of the prefrontal. The floor of the brain-case in front is supported by a vertical style, which is bifurcate above, and rests on the parasphenoid.

Of the *teeth*, in general, it may be added that their pulp cavity is rather large at the base, but rapidly diminishes in the crown. The mode of succession is by direct displacement from below. The young crown rises into the pulp cavity, and destroys the vitality of the crown, while the root is absorbed. Numerous empty alveoli are to be found in all the jaws of this genus, in which examination will often detect the apex of the crown of the young tooth.

The *vertebræ* in this genus are rather short, but not so much so as in sharks. In *P. thaumas*, nearly eighty dorsals and caudals were preserved; those without lateral grooves, or cervicals, are not numerous. There are, perhaps, not more than four vertebræ supporting the caudal fin, though this is difficult to determine, owing to the concealment of the terminal centra by bases of radii. There are seven hæmapophyses in the support, all flat except the first, which is like those anterior to it. The second is articulated freely to its centrum, and is wider than the others. Its condyle is characteristic, being double, and with a foramen between it and the produced extremity of posterior margin of the bone. It is slightly separated distally from the third, but the remainder are in close contact. The radii of the superior lobe of the caudal fin extend at least as far down as near the end of the third haemal spine from below. The structure of these parts in the *P. molossus*, are as in *P. thaumas*, so far as preserved.

As some of the *spines* are not referable to their precise species in this genus, they may be described here. A large compound spine found in the blue limestone shale in Fossil Spring Cañon, is composed at the base of about twenty-six narrow double rods. A few appear between the others beyond the base making thirty-one altogether. They are very oblique to the general base, but curve so as to become nearly straight, and enlarge distally. They terminate in a thickened portion which bears an acute edge, which truncates them obliquely, forming the cutting edge of the spine. This portion is enamelled; the edge is slightly convex at the base, and slightly concave at a point probably beyond the middle.

	M.
Length of fragment (12 inches)	0.30
Width at base	.12
Thickness at base	.012
Thickness at broken end an inch from edge	.007

This is a formidable weapon and could be readily used to split wood in its fossilized condition.

The third form of spine is represented in most of the species, but one series of rays with spine may not be referable to any of them. The latter is flat and curved, the convex edge trenchant beyond the middle. The posterior edge is obtuse but narrow, and exhibits a slight groove on one side medially; proximally there is a shallow rabbet whose floor is transversely rugose. Several layers of the tissue of the spine beyond the basal portion are delicately longitudinally striate. The distal half is broken away; length of fragment, one foot; width, 1.5 inches; thickness at middle, 5 lines.

The species of this genus may be distinguished as follows:

a, Teeth without acute edges.

Large maxillaries five; second premaxillary larger than the first; third mandibular large, behind a cross-groove; last large mandibular followed by 16.—8 small teeth..*P. molossus.*

Large maxillaries, three; first premaxillary larger than second; third mandibular small, no cross-groove in front of it; twenty small teeth behind last large mandibular................................*P. thaumas.*

aa, Large teeth with cutting angle in front.

Teeth large, not compressed..........................*P. angulatus.*

PORTHEUS MOLOSSUS. Cope.

(Proc. Amer. Philos. Soc., 1871, p. 173.)

Represented by four individuals, one from Fox Cañon, near Fort Wallace, with complete cranium, and many vertebræ and radii; a second from another part of the same ravine with large part of cranium, and a third and fourth from lower Butte Creek bluffs, both with fragments of cranium and other portions. In the first specimen the jaws are perfect and dentition complete.

The *premaxillary* is vertically oval, convex externally, nearly flat within, and more than half underlaid by an anterior lamina of the maxillary, The anterior or median margin is regularly convex and exhibits no surface or suture for union with the bone of the opposite side. Its posterior margin extends obliquely backwards to beneath the superior articular condyle of the maxillary and has a ragged margin, though the suture is squamosal. Its superior margin is deeply inflected in front of the condyle and then convex and thickened. The anterior margin is thick and rugose with tubercular exostoses. There are but two teeth, which are very large, and directed obliquely forward; the first is two-thirds the diameter of the second.

The *maxillary* is a large laminiform bone, with the upper margin considerably thickened proximally but much thinned distally. It is abruptly contracted at the distal two-thirds its length, apparently for the attachment of a supernumerary bone. The extremity is curved sabre-shape upwards, and has an acute toothless edge. The teeth are, four small, five large, and eighteen small. These teeth, except the largest, have cylindric bases; the crowns (and bases of the latter) are slightly compressed or

oval; they are straight and regular, and lean backwards. The middle one of the five is largest, being six times as long as the small ones, but little more than half as long as the large premaxillary or mandibular. The surface of the maxillary is rugose with small tubercles on its lower half, and has shallow grooves for nutritious vessels running downwards and forwards.

The *mandibular rami* are short and deep, and have but little mutual attachment at the symphysis. They are not incurved at that point, and were bound by ligament only. There is no coronoid bone and the articular is distinct. It is short, of a rather irregular wedge shape, and supports half the cotylus, above which it sends a short acuminate process. The angular has a prominent angle, like half an ellipse somewhat contracted at the base; below it has a rough prominent muscular insertion. The bone extends in a long sword-shaped process, on the inside of the ramus to beyond its middle; externally, it is soon covered by the thin truncate edge of the dentary. This element is very large. From the angular it rises steeply to a coronoid process, which has a slight outwardly twisted eminence, and then follows a gently concave line to the symphysis. The teeth are as follows: two large, a transverse groove; three large, four very small, nine medium, and two very small; total twenty. These teeth have straight cylindric-conic crowns, with enamel without striæ or facets. The larger are a little compressed.

Measurements of Jaws and Teeth.

	M.
Length premaxillary bone	.007
Depth " "	.093
Thickness on alveolar margin	.016
Length crown of second tooth	.046
Diameter do. at base	.014
Length maxillary bone from premaxillary	.270
Depth " at condyle	.08
" " at middle	.046
Length crown third large tooth	.028
Diameter do. at base	.011
Length crown second small tooth from large	.006
Diameter do. at base	.004
Length ramus mandibuli	.350
" of angle	.04
" of angular bone anteriorly	.08
Depth at coronoid process	.112
" at fourth tooth	.08
Length crown first tooth	.038
Diameter do. at base	.011
Length crown fourth tooth	.055
Diameter do. at base	.016

The *opercular bones* are thin; the operculum broad, the preoperculum

rather narrow. The latter is without armature, and has some depressed grooves radiating towards the circumference. Length of bone vertically, M. .245 ; radius from inner curve, .09.

The *vertebræ* display deep lateral grooves; articular faces smooth. Length centrum, M. .028 ; diameter, .043. The fan-shaped hæmal spines, or second of the caudal fin is like that of *P. thaumas*, but smaller. The last caudals contract in size very rapidly ; the cup of the penultimate or last is transverse diamond shaped.

The fragments of the sabre-shaped *spine* display several layers of parallel striate dense bone, and the edge is tubercularly dentate, and one side is much more rugose than the other. At the base, one side is flat; the other convex, and there is a transversely rugose band near one edge.

The *scales* are thin and cycloid, and though large are not remarkably so for the size of the fish.

Measurements of Cranium.

	M.
Length from angle of opisthotic to anterior extremity of ethmoid	0.30
Length from same to front of proötic	.11
" " postfrontal to prefrontal across orbit	.11
" " occipital condyle to transverse process of parasphenoid	.117
Length from do. to bottom parasphenoid emargination	.055
" parietal bone on outer suture	.07
Width do. at middle	.014
" do. to edge pterotic	.07
" frontal at middle orbit	.04
" parasphenoid do.	.03
Length inferior quadrate	.10
" condyle of do.	0.03
" symplectic	.064

The gape of the mouth of the *Portheus molossus* extended the whole length of the cranium proper, and far beyond the orbits, since the maxillary reaches to opposite the occipital condyle. The orbits were large. The lower jaw was deep, and gave the countenance that bull dog expression from which it derives its name. The body was short or moderately elongate. As materials for a restoration of this fish exist, I will give one at a future time.

PORTHEUS THAUMAS. Cope.

(*Saurocephalus thaumas*, Cope. Proceed. Amer. Philos. Soc., 1870, November. Hayden's Survey, Wyoming, etc., 1871, p. 418.)

This large species rests on a specimen without cranium, originally procured by Professor B. F. Mudge. The parts preserved are not distinguishable from the corresponding ones in two individuals obtained by myself in Western Kansas, which include the greater portions of the jaws

and suspensorial apparatus. These indicate larger animals than those of *P. molossus*, and probably indicate the most powerful of the Physostomous fishes, equaling in this respect many of the saurians which were their contemporaries.

The distinguishing features of the species have been already pointed out.

The *premaxillary* is an obliquely oval bone or subpentagonal; the suture with the maxillary is not toothed, and the anterior or free edge is smooth, not tubercular as in two specimens of *P. molossus*. There are but two teeth, of which the anterior is immense, and the second little more than half its diameter. The *maxillary* is stout, and supports in front four very small teeth, then three very large, of which the median is largest. The teeth recommence very small and closely placed in the same line; but as the extremity of the maxillary is lost, the number cannot be stated.

The *dentary* is similar in form to that of *P. molossus*, but has rather more numerous teeth. Counting from the front there are two large, one rather small, two large, and eighteen small and medium following, the smallest from third to ninth, inclusive. None of the crowns are preserved, but the alveoli are round or nearly so. The large tooth of the premaxillary if proportioned as in *P. molossus* must have projected M. .0755, or three inches above the alveolus; the fourth mandibular was but little smaller.

Measurements of Jaws.

	M.
Length premaxillary	.075
Depth "	.09
Depth maxillary at condyle	.08
Thickness " just behind condyle	.025
Length dentary	.25
Depth " at symphysis	.08

The various portions of *cranial bones* preserved are much like those of *P. molossus*, but stouter. The hyomandibular is nearly perfect: it is thin, but has a convex rib extending to its acuminate extremity at the posterior-inferior angle of the metapterygoid and the superior extremity of the symplectic. The preoperculum is attached by a thickened grooved margin, and is not overlapped by the hyomandibular. It extends in a curved form round towards the angle of the inferior quadrate. Three elongate bones, closely appressed, I suspect to be part of this bone, with interoperculum and superior ceratohyal. The last is rather narrow, and with smooth distal articular surfaces, without suture. The superior branchihyals are a little like phalanges of Mosasaurus in form, being sub-similar and expanded at the ends, and quite alternated. The parasphenoid is similar to that of *P. molossus*. The position of the hyomandibular is vertical to the axis of the basioccipital; the superior part directed forwards.

	M.
Length basi-occipital to end maxillary foramen	[illegible]
" hyomandibular	[illegible]
" inferior quadrate oblique	[illegible]
" condyle of quadrate	[illegible]
" præsphenoid preserved	[illegible]

A portion of one of the fin unsegmented spines preserved exhibits an irregular ribbet on each edge of one side; width .042 M. The sclerotic bones are as already described.

A second specimen is still stouter in proportions as the following measurements show:

	M.
Diameter maxillary condyle	.034
Diameter maxilla above, behind condyle	.035
Length angle jaw exteriorly	.056
Diameter parasphenoid at middle of orbit	.03
Diameter dorsal vertebra (crushed)	.067

The diameter of the vertebra must be a little corrected by reduction.

The largest fish vertebræ obtained may be here mentioned. They are peculiar in having numerous concentric grooves on the articular faces, as in *Ischyrhiza*. They are otherwise as in this genus. Length, M. .04; diameter, .062.

A peculiarity of *dentition* is observable in the two specimens first described, and in less degree in *P. molossus*. A considerable number of alveolæ support no functional teeth (though included in the enumeration), but are occupied at some point by successional teeth. In some cases the mouth of the alveolus appears to be narrowed by ossification, even where the tip of the young tooth is in sight; in one case so far developed as to close up to the projecting apex. In other cases the orifice is entirely stopped by the ossification, which presents the appearance of a scar, with radiating lines of pores.

The type specimen was discovered in a denuded area among the lower bluffs of Butte Creek. The flat cranial and jaw-bone occupied the summit of a cone of twenty or more feet in height, a relic of the ancient blue limestone spared from the surrounding denudation. The flat bones had shed off the water, which, running off on all sides, had formed the cone. The second specimen came from the Fossil Spring Cañon, near the remains of *Liodon curtirostris*.

Portheus angulatus. Cope.

The crown of the tooth which indicates this species is slender, compressed, and curved backwards, and a little inwards. The circumference is divided by two edges, the anterior acute, the posterior obtuse; the convex faces separated by these are not equal, that towards which the crown is curved laterally, *i. e.*, the inner, being somewhat more extensive, and considerably more convex.

Enamel smooth, without sculpture; anterior cutting edge without crenations, more curved backwards than the posterior, which has but little curvature. Inward curvature slight.

	Lines.
Diameter (anteroposterior) at middle crown	5
" transverse at middle crown	4
" " near tip	3
" anteroposterior, near tip	2

Discovered by Prof. C. Kerr, State Geologist of North Carolina, in the Miocene marl, Duplin Co., North Carolina, with Polygonodon rectus, and Ischyrhiza antiqua, Leidy.

ICHTHYODECTES. Cope.

(*Proceed. Amer. Philos. Soc.*, 1870, *Nov. Hayden's Geol. Survey, Wyoming*, etc., 1871, p. 421.)

Teeth equal subcylindric, in a single row, sunk in deep alveoli. Premaxillaries short. No foramina at the bases of the teeth on the inner alveolar walls. Vertebræ deeply grooved laterally.

The species of this genus are, so far as known, smaller than those of the last; and as their remains are more perishable than those, they form a less striking object among the fossils of Kansas. They are nevertheless, very abundant, especially in species, five of which are now described. In originally describing this genus, the vertebræ were regarded as not grooved, in consequence of such vertebræ having been discovered along with the bones and teeth of *I. ctenodon*. Further examination has satisfied me that this union is erroneous, and that the bones, if found together, were accidentally so.

Spines similar to those of the *Porthei*, but presenting certain differences, may be referred to this genus. The compound segmented spines cannot be ascribed to it, but the compound fulcrum-like spines are similar, though composed of fewer and stouter rods. Each of these, as it terminates at the cutting edge, give rise to a projection, giving it an obtusely and remotely serrate character. It is rugose with enamel deposit, and constitutes as effective a weapon of defense as that of *Portheus*. One, which is nearly perfect, contains fifteen pairs of rods, which expand at the base, as do the rays of a pectoral fin. Total length, M. .285; width, at base, .04; thickness beyond base, .006.

The femoral bones have already been described. The maxillary is not contracted at the end for a supernumary bone, as in *Portheus*.

The form of the inferior quadrate is like that of *Portheus*; in *I. anaides*, the groove for the preoperculum extends low down, and the symplectic has a wider exposure on the outer face than in *Portheus*.

In a series of vertebræ similar to those of this genus, those included in the basis of the caudal fin are not more than three in number.

The species are distinguished as follows:

Premaxillary teeth five; second most prominent; maxillary not concave; dentary with 30 teeth and bi-convex alveolar border, with obtuse extremity.................. *I. anaides.*

Premaxillaries (?); maxillary straight, large, with 40 teeth; dentary straight, not produced at end; teeth 26.... *I. ctenodon.*

Premaxillaries five; first most prominent; maxillary, narrow concave; teeth small; dentary with a hook at apex; teeth 25.. *I. hamatus.*

Premaxillaries seven; first most prominent, compressed; smaller.. *I. prognathus.*

Premaxillaries twelve; second most prominent, the bone much narrowed above; smaller........................*I. multidentatus.*

The English species of this genus is figured by Dixon in the Geology of Sussex, pl. xxxii.*, figs. 9 and 9*. I can find no letter-press or name relating to it, and cannot determine its specific characters from the fragmentary character of the piece of mandible figure.

ICHTHYODECTES ANAIDES. Cope. sp. nov.

Indicated by two individuals, one with both dentary bones and teeth, with vertebræ, the other with many portions of cranium, fin rays, vertebræ, and other elements more or less separated. The latter were all taken from the upper face of a spur of a limestone bluff, elevated about five feet from the ground level, where they were denuded and exposed as on a table, prepared for the use of the geologist.

It is the largest species of the genus, and the anterior premaxillary teeth are larger than the posterior. The *premaxillaries* are oblique ovoids, very convex on the external face, thinning laterally and above. The superior margin presents a thickening, bearing an articular surface, while behind it is an open gutter-like inflexion. The large teeth are quite cylindrical. Both these bones are preserved. But part of the right *maxillary* remains. It is thickened above in front of the condyle and is regularly convex at that point. The teeth are small, there being 10.5 in an inch. The margin is not concave.

The mandibular rami are preserved almost entire. They are short and deep, and have a short angular process, which is relatively shorter than in *Portheus*. The margin rises steeply to the dentary, which presents a narrowed rectangle behind. The alveolar margin has two convexities with a depression between; the symphyseal angle is not prominent. The lower posterior angle of the dentary is quite prominent for muscular insertion. The crowns of the teeth are cylindric, slightly curved inwards. The dentary bones of the second specimen coincide with these in all respects.

Thirty-three *vertebræ* are preserved, all deeply two-grooved on the sides. The ribs are articulated by a sigmoid surface to a broad short element of a sigmoid form which is inserted in the lateral groove of the inferior face, or articulated by gomphosis.

The spines already noticed are quite flat, without serrate edge, but with some rugosities near the edge on one side only. There are no grooves on the upper side, but the dense bone is delicately striate; distally grooved.

Measurements.

	M.
Length premaxillary	0.033
Depth "	0.045
Depth maxillary at condyle	.037
Thickness " just behind condyle	.012
Length mandibular ramus	.172
" angular process	.014
Depth at coronoid process	.058
" " symphysis	.041
Length of eight vertebræ	.212
Width of articular face	.030
" " a rib	.004
" flat spine at middle	.025
Length " (fragment)	.155
" condyle inferior quadrate	.02

The scales associated with this species were thin and cycloid, and dif-ficult to preserve.

From near the Smoky Hill River, Kansas.

ICHTHYODECTES CTENODON. Cope.

(Proc. Amer. Philos. Soc., 1870, Nov. Hayden's Geol. Surv., Wyoming, etc., 1871, p. 421 part.)

Found by Professor Mudge on the North Fork of the Smoky Hill River; common in many other localities.

ICHTHYODECTES HAMATUS. Cope. sp. nov.

Represented by a considerable number of remains of an individual from the blue cretaceous shale near Russell Spring, on the Smoky Hill River.

The characters which distinguish this species from *I. anaides*, are numerous, but they are less marked when compared with those of *I. ctenodon*, partly because the premaxillary bones of the latter have not been preserved. In the first place, the dentary bones of the two are of equal length and support the same number of teeth; it is concave at the proximal part of the tooth line, but is straight in the corresponding part of *I. ctenodon*. The end of the dentary is furnished with a strong obtuse process or hook, directed upwards and forwards, not seen in *I. ctenodon*. The maxillary behind the premaxillary is, in this species, thickened, and with two articular surfaces, the proximal looking outwards, the distal inwards and separated by an oblique ridge from the condyle. In *I. ctenodon*

there is but one smooth surface gradually narrowing with the thinning of the bone from the condyle.

The *premaxillary* is less extended antero-superiorly than in the species already described, but supports, as in it, an articular face. There is no groove behind it, as in *I. anaides* and *Portheus*. It displays a surface for osseous articulation to near its extremity on the inner side, while below it, and on the external face, near the basis of the first and second teeth, the surface is rugose; maxillary teeth 43. The dentary supports 25. The anterior hook is obtuse, and rises abruptly to above the apices of the crowns of the teeth. It is knobbed above, and supports a tooth not larger than the others.

All the cranial bones preserved are not sculptured.

Portions of the thin *flat spines* display the delicately-grooved striation already observed, while the trenchant edge is bordered on one side by raised *longitudinal* striæ. The other side is minutely pitted.

The vertebræ are anterior, and without lateral grooves. Three of them are M. .06 in length; an undistorted one is a little wider than deep, and the cup is .026 across.

Measurements.

	M.
Length ramus mandibuli	0.174
Depth at symphysis	.055
" premaxillary (oblique)	.043
Length " "	.026
Depth maxillary at condyle	.027
" " behind "	.033
" " near middle	.027
Width flat spine	.031

This species, and the two preceding, were not very unlike in size; the two following are smaller.

ICHTHYODECTES PROGNATHUS. Cope.

(Proceed. Amer. Philos. Society, November, 1870. (*Saurocephalus.*) Hayden's Geol. Survey, Wyoming, etc., 1871, p. 417.)

In this species the premaxillary is more rhomboid in outline than in the others, and is less convex externally. Of its more numerous teeth, the first is not larger than the last, differing thus from all others of the genus, and it is in line with the nearly straight anterior margin of the bone. It is more compressed than in the other species, whence I originally placed it in *Saurocephalus*. To this genus it does not belong, as the absence of marginal alveolar foramina shows. The surface of the bone is peculiar; in a minute sculpture of impressed lines, or lines of punctæ. There is a very small articular surface on the superior extremity.

From the North Fork of the Smoky River.

ICHTHYODECTES MULTIDENTATUS. Cope. sp. nov.

Here we have again the convex *premaxillary* of the larger species, with more numerous (12) teeth than in any other of the genus. These increase in size to the first three, the last being small. The second and third are about equally prominent, and more so than the first. The bone is much contracted above, there being an excavation on the anterior border and contraction from behind. The superior edge is thin, and *without trace of articular* surface. Alveolar edge somewhat rugose. The *maxillary* is both narrow and thin, but is only partially preserved. It bears five teeth on M. .01. One of these, with complete crown, displays a longitudinal angle on the antero-interior face.

No other remains were preserved.

	M.
Length of premaxillary	0.039
Depth " (oblique)	.023
Length of tooth line	.025

From near Fossil Spring, W. Kansas.

SAUROCEPHALUS. Harlan.

Leidy has pointed out the mode of implantation of the teeth in the typical species of this genus. The mode of succession of the teeth has not yet been indicated, but is well displayed in a specimen of the jaw of *S. arapahovius*, Cope. It is known, from Harlan's description, that a large foramen issues on the inner wall of the jaw, opposite each root. The fractured ends of the specimen exhibit the course of the canal which issues at this foramen. It turns abruptly downwards between the inner wall of the jaw and the fang of the functional tooth, and not far from the foramen. Its course is interrupted by the crown of the successional tooth. This is situated obliquely as regards the long axis of the jaw.

It is thus plain that, the successional appearance of teeth is different in this genus from what I have described in the two genera preceding. In them the foramen is wanting, and the young crown rises within the pulp cavity of the functional teeth, as in the *Crocodilia*. In this genus, on the other hand, it is developed outside of the pulp cavity and fang of the old tooth, and takes its place as in many *Lacertilia* and in the *Pythonomorpha*, by exciting the absorption of the latter. The obconic form of these fangs in *Saurocephalus* is appropriate to such a succession, and their great length seems to preclude the nutrition of the young tooth from their bases. The use of the foramina on the inner face of the jaw is thus made apparent, viz., the nutrition of the successional teeth from without. I cannot trace the canal below the crown of the young tooth to the base of the pulp cavity of the old tooth and there are canals in the jaw, below the latter, one of which probably carried the dental artery.

Species of this genus are less abundant in the part of Kansas examined by me than those of the preceding genera. Two only have been observed up to the present time, as follows :

SAUROCEPHALUS PHLEBOTOMUS. Cope.

(Proceed. Am. Philos. Society, Nov., 1870. Hayden's Geology, Wyoming, etc., 1871, p. 416.)

Solomon River Region. Prof. Mudge.

SAUROCEPHALUS ARAPAHOVIUS. Cope.

Established on a portion of a maxillary bone, with a part of a suture, perhaps for attachment to a supernumerary maxillary. The size of the species is nearly that of *S. lanciformis*, and the crowns of the teeth are rather short, as in that species, and less elongate than in *S. phlebotomus*. The teeth are very closely set, and the alveoli are separated by very narrow septa. The crowns are expanded, so that the edges overlap in some cases. The form of these is much compressed, width about equal to height, the edges convex and acute. The enamel is smooth and without facets. The roots are without the facets, shown by Leidy to exist in *S. lanciformis*, and appear to be longer than in that species, exceeding the length of the crown nearly four times. None are, however, perfectly exposed for complete measurement. As usual, there is a large foramen opposite each fang, below the inner alveolar margin, and between the latter and the series of foramina the surface is slightly convex and minutely rugose.

	M.
Depth of bone	.035
Thickness at rugose band	.0055
Total length of a tooth (?)	.02
Length of a crown	.0043
Width "	.0036
Number, etc., in an inch	8.

The size of this fish was probably about equal to that of *Ichthyodectes anaides* above described. Found loose on a cliff of blue shaly limestone, fifteen miles south of Fort Wallace, Kansas.

PACHYRHIZODONTIDÆ.

This family of Physostomous fishes differs from the last in the nature of its dentition. Instead of elongate conic fangs sunk in deep alveoli, it has shorter and stouter fangs occupying alveoli, of which the inner side and part of the anterior posterior walls are incomplete. The teeth are, in fact, more or less pleurodont, but the extremity of the root is received into the conic fundus of the alveolus.

The premaxillary bones are well developed, but the maxillaries are more so, and enter largely into the composition of the border of the mouth, There is a well-developed angle of the mandible, but no coronoid bone is preserved in the specimens. The coronoid region is, however, broken in all our specimens. The other characters of the family are not determinable from our imperfect materials.

PACHYRHIZODUS. Agassiz.

Dixon's Geology of Sussex, 1850, p. 374.

This genus was established by Prof. Agassiz, on a jaw fragment from Sussex, England, with a very brief description. The Kansas remains resemble this fragment in their corresponding parts, and I refer them to the same genus for the present.

The genus as seen in our fossils, is defined as follows:

Muzzle flat; premaxillary bones rather long, with two large teeth together, near the anterior end, behind the usual external series. Maxillary and mandibles with a single series of simply cylindric curved teeth. Mandibular rami closely articulated by ligament.

The teeth in this genus bear a superficial resemblance to those of a mosasauroid genus. Their mode of succession appears to be as follows:

The crown of the young tooth was developed in a capsule at the base of the crown, or on the inner side of the apex of the thick root. The absorption which followed excavated both the former and the latter, but the crown was evidently first shed. Finally, the old root disappeared, and when the new one occupied the alveolus, it left a free separation all round. Finally, on the accomplishment of the full growth of the root, it became anchylosed to the sides of the alveolus. The pleurodont position of the tooth facilitated the shedding of the root very materially.

The genus *Conosaurus*, Gibbes, from South Carolina, is, perhaps allied to this one. Its dentition is fully described by Leidy, who changes the name to *Conosaurops*, mainly on account of the inappropriateness of the Greek Σαυρος to a fish. This word was, however, employed by the ancients to designate a fish, and the only use made of the word out of composition, by modern zoölogists, is for species of that class, so that it does not seem improper to use it here.*

Three, perhaps four, species left their remains in the strata examined by the expedition.

PACHYRHIZODUS CANINUS. Cope. sp. nov.

Established on portions of, perhaps, two individuals, which embrace one nearly complete maxillary bone, two premaxillaries of opposite sides, two nearly perfect rami of the mandible, with numerous other portions in a fragmentary condition.

These indicate a cranium of about a foot in length, by six and a half in width, oval in outline, with moderately obtuse muzzle. The mandibular teeth are directed somewhat outwards; the premaxillary is horizontal in front, and the maxillary narrow. From these facts I derive that the head was probably depressed, as in the modern *Sauri*, and very different from the prevalent compressed form of the *Porthei* and allies.

* The case appears to me to be different with the name *Ischyrosaurus*, which I proposed to replace with *Ischyrotherium* (Leidy). The latter was given to a genus of saurians, under the supposition that it belonged to the *mammalia*, and the termination, *therium*, devoted to this group of animals by meaning and custom, cannot be applied to a sauriam by any stretch of metonymy or charity.

The *premaxillary* is several times longer than wide; posteriorly it is a subvertical plate; anteriorly it terminates in a narrow obtuse portion. Just behind this portion it is enlarged on the inner side, forming a knob, whose upper surface supports the articulation with the ethmoid. It bears the two large teeth below, on a common elevation of the jaw. The outer margin of the bone supports ten sub-equal teeth, which are one-third smaller than the posterior pair. The outer alveolar ridge is a little more elevated than the inner, though a little less so than on other bones which support teeth. The external face of the bone is nearly smooth, and the inner unites with the maxillary by striate squamosal suture.

The *maxillary* preserved is nearly perfect, and may belong to another animal; its depth coincides with that of the premaxillary. It is quite elongate, about nine times as long as deep, perhaps a little more. It supports forty-two closely packed teeth, not all in functional service at once. The distal end is contracted and grooved and ridged on the inner face, as though for union with a supernumerary bone. The external face is longitudinally striate on the posterior half, the striæ running out to the margins, forming sharp rugosities on the alveolar border. The superior (palatine) articular surface is more than one-fourth the total length from the anterior extremity; it is narrow and somewhat lens-shaped. Both behind and in front of it, strong striæ run from the outer to the inner side of the superior margin, sub-longitudinally. Posterior to the superior articular surface on the outer face is a swelling like a muscular impression, from which grooves and keel extend posteriorly. The bone is concave on the outer face in front, to accommodate the *os premaxillare*.

The *mandibular rami* are abruptly incurved at the symphysis, which is not serrate, is sub-round, with an emargination entering from the inner inferior side. The dentary bone is much narrowed behind. The *angular bone* extends anteriorly on the inner face to the end of the posterior, two-fifths of the dental line. The ramus is not very deep at the coronoid region. The articular cotylus is composed more largely of the angular than the articular. Its long diameter extends inwards and backwards, and is strongly convex; in the transverse direction, slightly concave. Below and in front of it the lower margin of the jaw is acute. The angle is oval and rather small, it is prominent on the middle line on the inner side, the edges are thin, the upper curved outwards, concealing part of the cotylus. There are twenty-nine teeth on the dentary, whose sizes diminish towards its extremities. Their roots are very large and longitudinally striate and porous. Opposite the interval between the first two teeth, there is a tooth exterior to the general row, and another on its inner side. They are not enlarged.

No *teeth* are preserved except on the maxillary. These are not very elongate cones, with round section, and well curved inwards. Dense external layer entirely smooth.

This species differs from the type *P. basalis*, Dixon, in that the radical portion of the tooth is less swollen, and more conic, and does not project above the exterior alveolar wall as in that fish.

Measurements.

	M.
Total length mandibular ramus	0.267
" of tooth line	.170
Transverse diameter of symphysis	.018
" " base of tooth	.004
Length premaxillary	.068
" " to large tooth	.01
Greatest depth "	.018
Diameter large tooth at base	.007
Length maxillary to first tooth	.171
Depth " at " "	.019
" " at last "	.014
" articular surface	.0245

Found by the writer near Fossil Spring, near Fort Wallace, in Western Kansas.

PACHYRHIZODUS KINGII. Cope. sp. nov.

Established on the proximal portion of a maxillary bone with the articular surface, and bases of twelve teeth. It is a species of nearly the same size as the last, but the bone contracts more rapidly than in that one, and presents a stronger interior longitudinal ridge. The superior articular face is smaller and narrower, being sub-crescentic, while the insertion-like tuberosity is nearer to it, and on the inner edge of the outer face, and connected with the articular face by a ridge, not separated by a groove as in *P. caninus*. The outer face is depressed below the articular face much more than in that species, so that its lower portion becomes more convex. The roots of the teeth are of the same length as in *P. caninus*, and as they are more numerous, they are more closely packed and more cylindric. Their pleurodont character is also more strongly marked. The superior surface of the bone is striate grooved longitudinally, and transverse or obliquely.

	M.
Total depth of bone at articular face	0.022
Depth at tenth tooth	.0155

This species was found near the preceding. It is dedicated to Doctor William Howard King, Post Surgeon at Fort Wallace, to whom, and not less to his excellent wife, I am indebted for hospitality and other assistance of a kind essential to the success of my explorations in Western Kansas.

PACHYRHIZODUS LATIMENTUM. Cope. sp. nov.

Represented by a right ramus mandibuli with the angle and cotylus deficient. The posterior portion of the dentary is also wanting, so that the number of teeth it supported is not ascertainable. The general form appears to have been deeper than in the *P. caninus*, while the size of the teeth is similar. The external face of the bone near the alveolar border is convex, and not particularly rugose. The external alveolar wall is well elevated above the inner. Below the latter, the dentary bone ex-

hibits a strong longitudinal ridge. The extremity of the dentary takes a wider curve from the symphysis than in *P. caninus*, giving a broader chin (whence the name) and muzzle. The symphysis is smooth transverse trilobate, the two outer lobes being separated by an emargination in the position of the foramen mentale. This form is very different from that in *P. caninus* where the symphyseal surface is sub-round.

The anterior teeth are smaller than the median, and have the inner alveolar wall nearly as much elevated as the external. The crowns are scarcely distinguishable from those of the *P. caninus*, being curved conic, with round section and smooth cementum. They form a single incurved row next the symphysis. Number of teeth in an inch at middle of ramus, 4.5.

From a cañon near the Smoky River near to the *Icthyodectes anaides m.*

PACHYRHIZODUS SHEARERI. Cope. sp. nov.

Associated with the bones of the *P. caninus* is a slender bone of oval section, which is marked on one edge by twenty-two transverse alveoli whose outer margin are a little higher than the inner. No teeth preserved. It may belong to a fish of this genus, and is probably a superior maxillary bone. Constantly with this position its outer extremity is more compressed than the proximal, the thickening being especially seen in the superior margin. A shallow concavity passes obliquely across this border from within outwards and distally as in *P. caninus*, but the articular face is not preserved. There is a longitudinal angle on the external face, and the superficial layer of bone is nowhere grooved or rugose. The pleurodont character of the tooth attachment is more marked proximally. Length of piece, M. .041; vertical diameter, .007; greatest transverse do., .0033.

This species is dedicated to Doctor Shearer, Assistant Post Surgeon, to whose interest in the subject, the Geology of Kansas is indebted for many useful discoveries.

EMPO. Cope.

In this genus the character of the teeth is quite similar to that of the preceding group, but the arrangement on the maxillary bone is different.

The characters are:

Maxillary teeth anteriorly in two series, an external marginal of subequal teeth, and an inner and superior of probably small extent, but which terminates anteriorly in two large canine teeth.

Only one species is known to me.

EMPO NEPAHOLICA. Cope. sp. nov.

Established on a portion of the right maxillary bone of a single individual. It displays the anterior squamosal suture for the premaxillary, and not far posterior to this on the superior margin, a concavity for contact with palatine, pre-frontal or other bone as the case may be. The posterior portion is lost. The premaxillary sutural margin extends at right

angles to the alveolar edge to beyond the middle line of the side of the maxillary. Above this point a process of the latter extends above the premaxillary for half an inch; it has a broad inferior sutural face; its upper margin is thin and oblique. A short truncate process rises behind the superior cotyloid surface. The teeth are cylindric conic, slightly incurved; on a margin of .035 M. there are five teeth and five vacant alveoli. The teeth of the inner row are much smaller, and on .017 M., there are eight bases. The bases of the two large teeth occupy .014. Depth of maxillary at large teeth, .019; at fractured end, .014. The anterior teeth of the external series are not larger than those of the inner.

The precise locality of the Niobrara chalk where this species was found has been mislaid. There is a possibility of its belonging to the *Pachyrhizodus latimentum*, but the smaller relative size seems to contradict the supposition. Should it be verified, the latter species must be referred to the genus *Empo.*

STRATODONTIDÆ.

In this group I have arranged several genera which resemble *Enchodus*, the longest known of its forms. They are Physostomous fishes as indicated by the relations of bones of the superior arch of the mouth; the absence of spinous dorsal radii; the cycloid scales, and the general relationship to *Esox*. Agassiz and others have regarded some of them as allied to *Sphyræna*; this opinion was probably derived from the consideration of the forms of the teeth which to some degree resemble those of *Sphyrænidæ* and *Trichiuridæ*. This is, however, like many other minor characters, one of those which appear in both of the great groups of osseous fishes.

The premaxillary is small, and supports a large tooth in *Enchodus*; in *Stratodus* it is also short and supports numerous teeth. In *Stratodus* the maxillary supports a few teeth, in *Cimolichthys* a larger number. Relationship to *Esox* is displayed by *Stratodus*, which has broad flat palatine bones closely studded with teeth in a brush, and where the maxillary teeth are reduced in size and number. The teeth are attached by the anchylosis of the base to the alveolar face of the jaw, resembling thus existing fishes, and differing materially from the families of *Pachyrhizodontidæ* and *Saurodontidæ* already considered.

The genera known to me are the following:

Premaxillary with numerous small teeth, maxillary with a few of the same; palatines covered with brushes of similar teeth, all with pulp cavity.......................... *Stratodus*.

Premaxillary (?) Maxillary with a single series of large teeth which have one cutting edge at base and two at apex. Dentary with inner series of large teeth which do not enlarge distally, and some series of exterior smaller teeth.. *Cimolichthys*.

Premaxillary with a single large tooth; dentary with an outer row of small and an inner row of large teeth, which are much larger at the distal end.................. *Enchodus*.

STRATODUS. Cope.

This genus is well characterized by its dentition, which is remarkable for the small size and large number of the teeth, and their peculiar form. I possess one premaxillary, a considerable part of the maxillary, and nearly the whole of both palatines, besides other bones of one species. These were found not very far from the remains of the *Cimolicthys semianceps m.* and it required some investigation to determine the relationship between them. I have, however, portions of the maxillary and premaxillary of *Cimolichthys*, and both of these elements are so very unlike those in *Stratodus*, that there can be no doubt of its independence. I have, unfortunately, no dentary bone of *Stratodus*, and the outer row of palatines resembles in some measure those figured in *Cimolichthys levesiensis*, Leidy, by Agassiz.

The *premaxillary teeth* are in two series. They are stout at the base and oval in section, and are contracted and flattened rapidly upwards. On this basis is set an oval sharp edged flat, or spade-shaped crown, the long axis of compression being placed at right angles to that of the compression of the apex of the base. This gives a barbed appearance. The *maxillary* teeth are similar in form, but are in but few rows. The *palatine* teeth are constructed on the same plan, but they are longer, and the bases are subcylindric and slightly curved. All the teeth possess a large pulp cavity.

The *premaxillary* bone displays some of the density of composition seen in *Enchodus*. Its upper anterior surface meets the inferior of an acute angle. It is a broad oval, and is slightly concave. The inner face forms a truncate rim round the bases of the inner teeth, and terminates in a vertical crest of dense bone. The external face is, on the other hand, perpendicular, and extends obliquely upwards and backwards. An acute anterior angle of the *maxillary* under-runs it below, so far as to exclude all but one or two of the premaxillary teeth from the outer row. The external lamina of the premaxillary forms an extensive squamosal suture with this part of the maxillary by overlapping it from above.

This arrangement shows a certain similarity to *Esox*, especially in the large number of palatine and small number of maxillary teeth. It differs materially in the lack of articular surfaces between the maxillary, palatine, etc., in the upward prolongation of the premaxillary, and the peculiar forms of the teeth.

STRATODUS APICALIS. Cope. sp. nov.

Established on one incomplete individual, as above mentioned.

The maxillary teeth are mostly smaller than the premaxillaries, and diminish in size posteriorly; there are four or five series of them anteriorly. Seven to nine rows on the palatine bones; they are slender and curved downwards from oblique bases, and cylindric in section; they contract to a neck and then expand into the ovate spade-shaped cutting apex. They are in every respect the largest of the teeth, some making

a half inch in length. Those on the inferior or outer margin are most slender; those of the inner stouter and more conic. All the spade-like apices are black in the specimen, while the shanks are pale, except the premaxillaries. The *palatine bones* are flattened in one plane, and contracted at both ends. At the anterior, there is an external concavity perhaps for maxillary or premaxillary. A ridge divides the upper surface lengthwise; the outer edge is thin posteriorly, and there are two long grooves which extend to the posterior extremity, probably for sutural union with the pterygoid. The *premaxillary* bears a slight resemblance to the mandibular bone of a Chimæroid turned upside down.

	M.
Length portion of an *os palatinum*	0.128
Do. restored	148
Greatest width	.02
" thickness on margin	.003
Length premaxillary, fragment	.043
" " inner side	.025
" " outer to maxillary	.012
Width " in front above	.01
Length premaxillary tooth	.005

This fish was considerably larger than *Esox reticulatus* or *E. lucius.* In the lack of mandible its habits cannot be fully inferred, but the armature of the superior bones of the mouth is less powerful relatively than in those fishes.

Found by myself in the blue limestone shale on Butte Creek, south of Fort Wallace, Kansas.

CIMOLICHTHYS. Leidy.

Proceed. Acad. Nat. Sci. Phila., 1856, p. 202. Trans. Amer. Philosoph. Soc., 1856, p. 95. *Saurodon*, Agassiz, pt. Poiss. Foss.

In this genus the principal teeth are stout, and have a compressed apex with a prominent anterior cutting edge, and a less extended posterior one. There are several series of smaller teeth external to the large ones in the lower jaw, while in a portion of an upper jaw of one of the species these are wanting. Where present, they are more acute than the larger ones. The large teeth diminish gradually in length to the symphysis, a circumstance which separates these fishes from *Enchodus*, where one or more of the anterior teeth are elongate. In the species here described, the bases of the teeth are enlarged and deprived of cementum coat, but there are no true roots.

The maxillary bone terminates in a narrowed extremity with obtuse termination as in *Stratodus*. The vomer in one of the species is acuminate at one end, and supports a short series of teeth, the middle portion in a double row. All the teeth are without pulp-cavity.

The only indication of the mode of succession of the teeth is furnished by the specimen of *C. anceps*. Here a small excavation appears on the

inner side of the basis of the tooth. The absorption commencing at this point no doubt removes the bases so that the crown falls away.

The name used was applied by Dr. Leidy to a fish erroneously referred by Agassiz and Dixon to *Saurodon*, Hays. He did not characterize it, and until the barbed palatine teeth characteristic of it are discovered in our species, their reference to it will not be fully established. In the parts preserved they appear to be identical.

The general affinities of the genus will receive new light from materials now in my possession and not yet developed.

The *Sphryiæna carinata*, Cope (Hayden's Rept. Wyoming, etc., p. 424), probably belongs to *Cimolichthys*.

CIMOLICHTHYS SULCATUS. Cope. sp. nov.

Indicated by a left dentary bone with attached parts of angular, etc. The fragment supports thirteen teeth at equal distances, the intervals often presenting traces of tooth bases. The bases of the teeth are round and the crowns become compressed to the tip. They are strongly curved backwards and acute. The anterior margin is particularly convex and acute, forming a cutting edge, but there is no edge on the posterior face. The surface is rather finely striate-grooved on the inner and posterior faces. The teeth of the exterior series are in several rows, that next the large teeth being considerably larger than the others. They are curved inwards and are flattened, having cutting edges on both anterior and posterior margins. Cementum smooth. The external smaller teeth are shorter in relation to their length, not curved, and two-edged.

The dentary bone contracts irregularly to the symphysis, and has a thickened inferior margin. The symphyseal surface is small, and presents a marked fossa. The external face of the bone is divided by a deep longitudinal groove which is overhung by the produced extremity, and which gives exit to the mental foramen. The external face of the dentary has an impressed groove along its lower third anteriorly, and its surface is sculptured with deep longitudinal sulci, which often run together.

	M.
Length of fragment	0.18
Depth of first tooth	.01
" seventh "	.028
" tenth "	.045
Total elevation of fifth tooth	.014

The restored cranium of this fish is about one foot in length.

From near the Smoky River in Western Kansas.

CIMOLICHTHYS SEMIANCEPS. Cope. sp. nov.

Established on remains of two individuals. One of these embraces vertebræ, portions of vomer, maxillary, mandibular and other bones with some scales. The other consists of a dentary bone with symphysis and teeth.

These indicate smaller individuals than that typical of *C. sulcatus*, but the principal difference is to be seen in the teeth. These are rather more elongate, and they have a cutting edge on the posterior aspect of the apex as well as on the anterior. It extends but a short distance while the anterior rises near the base, and is strongly convex. The tooth curves backwards; the base is round in section. The convex posterior and the inner faces are rather finely striate-grooved. The larger teeth of the external series are convex on the inner face; they are two-edged, and slightly incurved.

The outer face of the *dentary* bones is strongly longitudinally parallel sulcate. The inner face and the surfaces of all the other bones are minutely striate exactly as in some of the *Mosasauroids*, *Clidastes propython*, for example. The anterior extremity of the *maxillary* is straight on one side, and obliquely beveled on the other to an obtuse compressed apex. The bevel becomes sub-horizontal posteriorly, indicating a rather shallow bone. Two of its anterior teeth are a little larger than those that follow. The supposed *vomer* is narrowed to a beak posteriorly (?), and presents an elevated longitudinal and obtuse ridge on the middle line. This supports a row of nine teeth, five of them having mates. The bone expands at the other end for a squamosal articulation with other elements. The vomerine teeth are smaller than the larger dentaries.

The *vertebræ* are elongate and much contracted medially; the rims of the cups are thickened, and the cups themselves very deep. There is a trace of a single median longitudinal groove. The neural and hæmal arches are represented by broad longitudinal laminæ in the specimens. The vertebræ are thus very different from those of the *Saurodontidæ*, and bear more resemblance to those of *Cyprinodontidæ*.

In the *ramus* with symphysis, the characters of the latter resemble those in *C. sulcatus*. It is very small, and does not exhibit the fossa of the latter species. The mental foramen does not continue as a groove to the edge, while there is a deep groove on the inner face opposite to it, not seen in *C. sulcatus*.

The first described specimen would have been, perhaps, a twenty-five pound fish in life. Both specimens were from near Butte Creek, at some distance apart.

CIMOLICHTHYS ANCEPS. Cope. sp. nov.

Established on portions of a right maxillary bone of one individual, and, perhaps, the premaxillary of a second. The former supports six teeth and four empty alveoli.

In accordance with characters derived from study of *C. semianceps*, there is no external series of smaller teeth on the maxillary. The maxillary has a flattened anterior extermination, somewhat as in *Stratodus apicalis*, the superior face being excavated and widened and gradually descending to meet the inferior. The line of junction, where also the premaxillary commences, is oblique from before inwards, and backwards. The anterior tooth is a little larger than those following. The form of

the teeth differs much from that seen in the species just described. They have an oval section at base, but speedily become much compressed in a direction oblique to the long diameter of the bone, and develop cutting edges opposite to each other, and separating equal faces. The crown is a little more convex on one edge than on the other, and has a slight inward curvature. The apex is sharp. The cementum of the crown is smooth, but the surface of the basal portion below the commencement of the cutting edges is minutely striate-grooved, some grooves being deeper than others, the surface having a silky lustre.

The surface of the bone where preserved is without special sculpture. The upper margin is grooved for articulation with a supernumerary maxillary.

	M.
Teeth in M. .01, two..	
Length of last maxillary tooth...........................	0.008
Long diameter of basis of "	.004
Depth maxillary bone at "	.012

The premaxillary bone belonged probably to a smaller fish. It has the characters seen in *Enchodus* but is shorter and deeper than in the known species. The lateral groove is here subvertical and on the anterior face extending to near the basis of the tooth. The inferior face behind the tooth expands gradually to its base, which is marked by the narrow crescentic scar of the older tooth seen in *E. pressidens*. The crown of the tooth was scarcely as large as that of the maxillaries, but is lost. Its basis is fluted, and the surface finely striate. Length of bone, M. .015. This specimen was not found with the preceding. The latter was discovered on the same bluff that produced the *C. semianceps* and the *Stratodus apicalis*, at some distance from them.

CIMOLICHTHYS GLADIOLUS. Cope. sp. nov.

Represented by a single elongate tooth which is intermediate in character between those of the two species last described, but much larger than either. It is too large for an anterior maxillary tooth of *C. anceps* and should it pertain to the end of the mandibular series, will in so far resemble the genus *Enchodus*. But the cutting edges are opposite to each other, and not, as is usual in that genus, on one side, leaving the inner face very convex. In this species the crown is rather slender and compressed above the base. The anterior cutting edge extends to the bottom, while the posterior reaches only half-way down; there is no barb. The section of the base exhibits an angle in continuation of the latter. The inner face is a little more convex than the outer; its posterior half is rather coarsely striate keeled. The posterior half of the outer face is finely striate. The inner posterior aspect of the root presents a cavity of absorption for the successional tooth, as in *C. anceps*. The cutting edge and top of apex are glossy black. Length from fossa, M. .019; diameter at do., .006.

From a locality at a short distance from that of *C. anceps*.

ENCHODUS. Cuvier.

Remains of species of this genus occur in the cretaceous strata of Kansas. I discovered a tooth belonging to one of them, in the matrix beneath the vertebræ of *Elasmosaurus platyurus*. Dr. Leidy describes a species* from the cretaceous formations of the Upper Missouri region, which he called *E. shumardii*. The premaxillary of a rather large species was obtained by my expedition, but the species is not determinable. The diameter of the basis of the tooth is M. .012. The long tooth of a species of medium size was detected, as follows:

ENCHODUS CALLIODON. Cope. sp. nov.

Enchodus sp. Cope. Hayden's Surv., Wyoming, etc., p. 424.

The tooth on which this species rests is especially elegant. It is quite slender, and gradually contracts to the acute apex. The cutting edges, which extend to the base, are on one side, and are separated in one direction by a narrow, slightly convex, and perfectly smooth face. The inner face is strongly convex, being more than half a circle from the middle of the length downwards. This is also smooth on its anterior and posterior aspects, but on the inner, there are nine sharp delicate keels which disappear as the tooth contracts, the last terminating with the third quarter of the length. Total length, M. .02; longitudinal diameter at base, .0025; transverse do., .0035. The apex of the tooth is black.

From near Fossil Spring, Western Kansas.

(?)——————

ANOGMIUS. Cope.

(Proceed. Amer. Philos. Soc., 1871, p. 170.)

This name was applied to a genus supposed to be allied to the *Saurodontidæ*, and represented by vertebræ only. One species was named *A. contractus*, Cope, l. c., which was found by Professor Mudge. I have seen nothing resembling these vertebræ among either of the three families above described, and cannot ascertain their exact affinities without further investigation. It is clear that they are not referable to the known genera of *Saurodontidæ* nor of *Stratodontidæ*. They present a marked character in the crowding together of those caudal vertebræ which precede those that support the caudal fin. The centra are shortened and the prolonged neural and hæmal arches and spines lie one on the other, forming a fan-shaped body. The arches do not, at the same time, become anchylosed. This structure is seen in the *A. contractus* and in a second and smaller species. It finds a parallel in the caudal vertebræ of the genus *Ischyrhiza* of Leidy from the green sand of the New Jersey cretaceous, where all the elements of this fan-shaped body, centra, spines, etc., are coössified into a solid mass. This will define family. A species having the same structure is common in the Miocene of Maryland. In

* *Enchodus shumardii*, Leidy, Proc. Ac. Nat. Sci., Phil., 1856, p. 257, is a smaller species than any of the Cimolichthyes here described.

Anogmius, the sides of the centra, though lacking the grooves of other genera, are striate-grooved and reticulate. So are those of *Ischyrhiza*, and both in this resemble the recent genus *Esox*. Add to this the fact that the teeth of *Ischyrhiza* are almost exactly like those of *Esox*, especially as to their large fissured fangs, and half pleurodont insertion, some relationship to the *Esocidæ* may be predicated. This is the first hint I know of as to the affinities of *Ischyrhiza*.

Anogmius contractus was about the size of *Ichthyodectes prognathus;* the second *Anogmius* is not more than one-third the size, the caudal vertebræ are more aggregated, and the neural spines after leaning backwards are turned upwards. The specimen came from Lower Butte Creek; no parts of cranium or fins were found. The vertebræ originally described by me as pertaining to *Ichthyodectes ctenodon* belong either here or to *Ischyrhiza;* they agree with the latter in most respects, having the neuropophyses coössified with the centrum. They are several times larger than those of *A. contractus* and relatively shorter, being about equal to those of *Ischyrhiza mira*, Leidy.

I do not name these species, as they may be *Pachyrhizodontidæ*, and will be in any case better identified from cranial and fin remains.

SELACHII.

Remains of sharks and rays are far less abundant in the cretaceous of Western Kansas than in New Jersey, and are much exceeded in abundance by the Physostomus *Actinopteri*, as the present account indicates. In the region near Fort Hays and Salina, sharks' teeth are more frequently found. Those from near Fort Wallace belong to but two species of the genus.

GALEOCERDO. Müll. Henl.

Galeocerdo crassidens. Cope. sp. nov.

Established on two teeth of the type of *G. aduncus*, Agass., *i. e.*, with one cutting edge much more convex than the other. The processes of the fang are rather narrow, that beneath the convex cutting edge the most so. The apex of the tooth is very short, entirely plane, and stands over the middle or inner edge of the wider process of the fang. The shorter cutting edge is straight or convex to near the base, where a short divergent keel develops itself. The anterior edge is strongly convex, and all the edges are denticulate. One side is more convex than the other. No denticles. Cementum smooth.

	M.
Length basis	0.014
Height crown	.01
" root	.005
Width tooth at contraction	.01

Galeocerdo hartwellii. Cope. sp. nov.

This species is of the *edgertonii* group, *i. e.*, with the cutting edges sub-equal and symmetrical. The basis is broad and with convexities of

the fang instead of the processes of the last species. The external parts of the cutting edge rise slowly from the base, and then rise more steeply at an obtuse angle. They are convex on each side above, and meet symmetrically, forming a little less than a right angle. No denticles; cementum smooth. Edge everywhere denticulate. One side of crown plane, the other convex.

	M.
Length basis	0.0115
" fang	.0495
Elevation of apex (from concavity)	.0145
Width crown at contraction	.042

This tooth is stouter and larger than that of *G. edgertonii*, and was found beneath the bones of the *Protostega gigas*. It is named after Martin V. Hartwell, a member of my expedition, to whose acuteness and industry I owe many specimens.

GENERAL OBSERVATIONS.

The following species have now been described from the cretaceous formation of Kansas:

SAURODONTIDÆ.

Portheus molossus. Cope.
Portheus thaumas. Cope.
Ichthyodectes anaides. Cope.
Ichthyodectes ctenodon. Cope.
Ichthyodectes hamatus. Cope.
Ichthyodectes prognathus. Cope.
Ichthyodectes multidentatus. Cope.
(?) *Xiphactinus audax*. Leidy.
Saurocephalus phlebotomus. Cope.
Saurocephalus arapahocius. Cope.

PACHYRHIZODONTIDÆ.

Pachyrhizodus caninus. Cope.
Pachyrhizodus kingii. Cope.
Pachyrhizodus latimentum. Cope.
Pachyrhizodus sheareri. Cope.
Empo nepaholica. Cope.

STRATODONTIDÆ.

Stratodus apicalis. Cope.
Cimolichthys sulcatus. Cope.
Cimolichthys semianceps. Cope.
Cimolichthys anceps. Cope.
Cimolichthys gladiolus, Cope.
Cimolichthys (?) *carinatus*. Cope.
Enchodus calliodon. Cope.

FAM (?)

(*Apsopelix sauriformis.* Cope. Hayden's Report, Wyoming, 1871, p. 423.)

SELACHII.

Galeocerdo crassidens. Cope.
Galeocerdo hartwellii. Cope.

Of the preceding twenty-four species, the greater part are Physostomous *Actinopteri*, and there is no species of a Physoclystous family in the list.* No trace of spines or scales of fishes of the latter character have been yet discovered in strata of this period in the West, though one (*Beryx insculptus*, Cope,) has been discovered by Dr. Lockwood in the green-sand marl of New Jersey.

In the second place, it is of importance to observe that the genera have nearly all been obtained from the chalk of Europe. *Portheus* is represented perhaps by some specimens referred to *Hypsodon*; one species of *Ichthyodectes* is figured by Dixon from Sussex, and one of *Cimolichthys* and *Pachyrhizodus* each. *Enchodus* has long been known from Holland, etc., *Apsopelix*, *Empo* and *Stratodus* being so far the only ones not found in Europe. This is of much interest in every respect, and points to the synchronism as generally understood, between the chalk formations of Kansas and of England.

Stated Meeting, February 16, 1872.

Present, 16 members.

President, Dr. WOOD, in the Chair.

A carte de visite photograph and letter, acknowledging receipt of diploma of membership was received from Prof. Charles H. Hitchcock, dated Hanover, N. H., February 3d, 1872.

A photograph was received from Rev. E. R. Beadle, dated 1824 Delancey Place, Phila., Feb. 7th, 1872.

Letters acknowledging the receipt of diplomas of membership were received from the Rev. E. E. Hale, dated Roxbury, Mass., Feb. 5, and from Mr. Edward Quincey, dated Dedham, Mass., Feb., 1872.

* In describing *Elasmosaurus* I state that remains of six species of Physoclystous fishes were found in the matrix surrounding the bones. This statement was founded on the assumption of previous authors, that the forms of fishes above described were related to *Sphyraena*.

A letter accepting election to membership was received from Prof. G. W. Hough, dated Dudley Observatory, Albany, Feb. 1, 1872, sending also a donation for the Library.

Letters acknowledging the receipt of the Publications of the Society were received from the I. Academy at Vienna, Jan'y 7, 1871 (XIII., iii. 81, 82); R. Society at Upsal, Nov. 1, 1870 (77, 78, 80, 81, 82); R. Library at the Hague, Aug. 27, 1870 (XIII., iii. 82); July 15, 1871 (XIV., i., iii. 84, 85); Holland Society at Harlem, June, 1871 (XIV., i., ii., 84, 85); Batavian Society at Rotterdam, Sept. 23, 1870 (XIII., iii., 82, 83); July 26, 1871 (XIV. i., ii., 84, 85); Royal Academy at Amsterdam, Dec. 15, 1869 (XIII. iii., 81, 82, 83); R. Academy at Brussels, Aug. 30, 1870 (82, 83); July 15, 1871 (XIV. ii., 84); Society of Physics, &c., at Geneva, Oct. 1, 1871 (XIV. i., ii., 84, 85).

Letters announcing the envoy of publications to this Society were received from the Im. Academy at Vienna, Sep. 26, 1871; R. Society at Upsal, Nov. 1, 1870; Observatory at Prag., Sep. 22, 1871; Geological Society at Dresden, Oct. 15, 1871; Central Scientific Bureau at Harlem, July 30, 1871; Batavian Society at Rotterdam, May, 1871; R. Academy at Amsterdam, Oct. 24, 1870; R. Academy at Brussels, July 25, 1871.

Donations for the Library were received from the Société Imp. des Naturalistes at Moscow, Royal Society and Observatory of the University at Upsal, Royal Prussian Academy, Verein für Erdkunde at Dresden, Natural History Society at Bamberg, K. K. Observatory at Prague, M. Barande, Holland Society at Harlem, Royal Academy at Amsterdam, Batavian Society at Rotterdam, Royal Academy and Observatory at Brussels, M. Quetelet, Physical Society at Geneva, Geological Committee of Italy, Signor Anianelli, of Naples, Geographical Society at Paris, Bureau des Longitudes, Revue Politique, M. Chabas of Châlons sur Saône, the Essex Institute, Boston Public Library, Dudley Observatory, Mr. W. W. Mann, of New York, Medical News and Library, Half Yearly Abstract of Medical Sciences, Penn Monthly, U. S. Secretary of the Interior, and Prof. J. S. Newberry, of the Ohio Geolog. Survey.

The Committee on the observation of the next transit of Venus, made a report, with a memorial to Congress, to be signed by the officers of the Society, and another, of like import, to be signed by members of the Society, and others who may be disposed to join in the object proposed.—The report was accepted, and the Committee discharged, and the memorial directed to be signed by the officers of the Society.

A paper was read by Mr. P. E. Chase, on the Correlation of Cosmical and Molecular Forces, which was referred to a Committee, consisting of Profs. J. F. Frazer, E. O. Kendall and S. J. Gummere.

Prof. Cope laid upon the table certain fossil remains from Utah, and presented a paper descriptive of their geological positions and relations, entitled, "On Bathmodon, an extinct genus of Ungulates."

A memoir on the Geology of West Virginia, by J. J. Stevenson, was presented by J. F. Frazer, and referred to the Secretaries.

Pending nominations Nos. 689–691, and new nomination No. 692, were read, and the meeting was adjourned.

Stated Meeting, March 1, 1872.

Present, 18 members.

Vice-President, Prof. J. C. Cresson, in the Chair.

A letter was received from Mr. S. W. Roberts, accepting his appointment to prepare an obituary notice of Mr. E. Miller.

A letter of envoy was received from the R. Society of Antiquaries, London, Feb. 26, 1872 (XIV. iii. 87); Boston Public Library, Feb. 28, 1872 (XIV. iii.); N. York Hist. Soc. Feb. 26, 1872 (XIV. iii.); Mass. Hist. Soc., Feb. 26, 1872 (XIV. iii.).

Donations for the Library were received from the R. Belgian Academy, Revue Politique, London Nature, Royal Society, R. Astronomical, Chemical and Antiquarian Societies, and Society of Arts and Institutions in Union, H. M. Sec. of State for India, Greenwich Observatory, Geological and Polytechnic Society of West Riding of Yorkshire, Leeds Phil. and Lit. Soc., Belfast Flax Extension Association, New Bedford Public Library, Prof. C. H. Hitchcock, Boston Old and New, American Academy of Arts and Sciences, New York American Chemist, Philadelphia Journal of Pharmacy, Bureau of Secretary of War at Washington, and the University of Virginia.

The Committee to which was referred Prof. P. E. Chase's paper on the Correlation of Cosmical and Molecular Forces, reported in favor of its publication in the Transactions, which was so ordered.

Mr. Lyman presented, for the Transactions, a description of a part of the Coal region of Southern Virginia, with an accurately surveyed map of the same, which was referred to a Committee, consisting of Mr. Lesley, Prof. J. F. Frazer and Dr. Genth.

Prof. Cope read, by title for the Proceedings, two papers, entitled, "On two new Ornithosaurians from Kansas," and "On the genus Protostega, a form of Extinct Testudinata," which were referred to the Secretaries.

Mr. Price read the first portion of a Communication entitled, "Another Phase of Modern Philosophy."

Prof. Stevenson's paper, read at the last meeting, was, on motion of the Secretary, referred to a Committee, consisting of Dr. Genth, Mr. Lesley and Prof. Frazer, Jr., to report on the propriety of publishing it in the Transactions of the Society.

The Report of the Treasurer of the Trustees of the Building Fund was read by Mr. Marsh.

Pending nominations, Nos. 689 to 692 were read.

And the meeting was adjourned.

ANOTHER PHASE OF MODERN PHILOSOPHY.

By E. K. Price.

(*Read before the American Philosophical Society, March 1st,* 1872.)

"All flesh is not the same flesh." "There is one flesh of men and another of beasts." "What is a man profited if he shall * * * lose his own soul?"

Those who have lived through nearly three-fourths of the Nineteenth Century, and witnessed the many useful and brilliant discoveries that have illustrated the past two ages, may not safely venture to discourage the boldness of any investigations that are legitimately pursued. Nor will any one properly criticise or censure those who in the main are doing good service to science, unless he clearly perceives that the great canon of philosophizing, which all must acknowledge, has not been duly observed. When such case occurs in matters of highest importance, it then becomes the duty of the humblest to speak out in the correction of what he believes to be error, in the name of an all-pervading philosophy, and in behalf of our common humanity, according to his own conviction and ability.

The first lesson the scientist should learn is that of the limit of the human understanding, beyond which it is useless to attempt to investigate; and to recognize as inviolable those secrets which the Creator has chosen to reserve to Himself, and to which there is no response to interrogation. The second, is to make sure of all the facts requisite to the ascertainment of truth, and thence to draw only such conclusion as the known facts will justify.

The physicists of this century have studied life from its physical basis, and have too often made the life and the mind of man the product of matter. I propose to discuss this theory, particularly in review of Professor Huxley's Physical Basis of Life, both to show that he has drawn his conclusions upon inadequate facts, and that he has left out of view the facts that show the distinctive nature and operations of the life and of the mind.

Let us first consider a few of the subjects having a bearing upon his theory, wherein the limit to knowledge is recognizable, beyond which further research is sure to be baffled. Nothing is more familiar to us than our own life. It is that self we should best know; and we can and do know many things about it; indeed all about it, except the mystery how it can possibly be, and can carry on its own functions. We can see and dissect our bodily structure of bones, joints, muscles, tendons; brain, nerves, tissues; heart, arteries, veins, etc. We see and feel the body's functions as they are carried on. We see how it is fed with food, and how the circulations are kept going and the strength is maintained; and know that the food taken is transmuted into the living being. We are invited to eat and drink to appease hunger and thirst, and thereby we both avert greater pain, and enjoy pleasure. The food is dissolved by the gastric juice secreted by the stomach, and is then *chyme*. This in its de-

scent receives the juice of the *pancreas*, and the bile from the gall-bladder of the liver. The action of the stomach keeps its contents in motion; and one portion, unfitted to enter the life-process, is rejected into the draught; the other called *chyle*, is a milky fluid, which the *lacteals* opening into the intestines imbibe and carry to the thoracic duct and into the venous system. The heart propels the crimson blood that is returned to it by the veins, together with the contributions of chyle, upon the lungs, where it meets the oxygen of the air, is decarbonized, and becomes scarlet; and this bright red blood, being returned to the heart, is propelled through the arteries to the extremities of the body, freighted with all the material the system demands; the corpuscles for bone, muscle, tendon, tissue, etc., and delivers them as and where wanted, and from the extremities the blood is returned through the veins to the heart. The process of life is carried on by ceaseless pulsations. The heart throbs; the arteries expand and contract; the stomach, the diaphragm and chest expand and contract; the lungs are kept in play, and we breathe; the intestines are operated by the peristaltic motion, and the glands and absorbents are ever at work. All this we perceive, or the anatomist or physiologist does for us, and to him all is as familiar as things of daily observation. But can he tell us what life is, or how it acts with an intelligence surpassingly wonderful? We see in this process that the food has become part of the living being; and it will remain such so long as it is useful to the creature, and when any part becomes useless in the animal economy it is rejected, so that after a few years the whole system is composed of new materials, but the same life of identical consciousness has survived, and may survive more than ten entire changes of the life-molecules. It is the life in the body, and only the life that has had power to take in, digest, and assimilate the organic food we eat, and make it part of itself. Why or how the thing we call life can do all this, no microscope reveals to our sight; no skill of dissection can reach it; no cunning of thought can teach us. We only witness the process and the fact of life. The Power that created the life, and endowed it with its wonderful intelligence, has chosen to keep this secret to Himself; and though it is ourself, and we are always conscious of its presence and action while we live, we can never tell what it is, or how it lives. We must accept it as an ultimate fact; but from that fact we may, if we are logical, infer that it had an Author, who could create it, and yet permit us never to know His secret, though that secret be our own life. The unknowable is thus dwelt upon not only to heighten our conception of Deity, but to show where time and labor would be spent in vain; and also, because it is salutary that all who investigate science should do so with the humbling consciousness that all that is known bears a very small proportion to that which here cannot be known. Yet, from the known, from the evidence of its design, and power, and beneficence; its obedience to law, and harmonious movements; its grandeur and glory, we surely infer a Creator, Almighty and Omniscient.

Let us go back a stage in the being of this life, whose source and nature we are invited by Dr. Huxley to investigate. From a vitalized ovum, seemingly but a speck of jelly, the fœtal being is developed into a body, with every part prepared to begin the hardening process of breathing life. Until birth it derives its nourishment from the mother by the umbilical cord attached to its navel. In due time it is expelled, by nature's timely effort, that child and mother may continue to live. The physical ligament that united them is severed, and the separate life begins. The child now breathes for itself, and takes food into its own stomach. Still the nourishment comes from the mother, and nature has provided it, as wanted, in her breast. At those fountains the child drinks by a process its instinct has already taught it. Its food is that adapted to enter into its circulation and nourish its life. The lacteal ducts absorb the milk and carry it into the current of life. Why this should all be, we readily understand; but how this harmonious process takes place, with such sure observance and beneficent end, we cannot penetrate. We say that nature and instinct do that we so admiringly behold. But if nature had an Author, then it was God who does it, to continue our race. Yet He retains the secret He chooses not to reveal.

But we must recede yet further to reach the physical beginning of life. In animals and vegetables of highest organization, we find that there are two sexes requisite to the reproduction of life. We will take the illustration from the vegetable kingdom, whence the inference may be made to the animal, including man. When the sun's warmth revisits us, and spring has come with her showers, we have also the flowers. These are not only for our pleasure and refinement of taste, but they are nature's bridal habiliments. The two sexes may be found in the same blossom; or in separate blossoms on the same, or different trees. The base of the pistils contains the female ovules, made but to perish in sterility unless they shall receive the pollen formed in the anthers of the stamens; but are not permitted to perish, for the breezes are ever transporting the dust of the pollen to the awaiting ovules; and the busy bee and insects, as they flit from flower to flower, assist in nature's requirement. In the speck of male dust is the beginning of life, to find its necessary receptacle in the female molecule of matter. The ovules are fructified; the flower fades and dies, for it has fulfilled its office; but the seed grows and matures, and is the germ of another life, that shall be like unto the parent. All this is watched, and surely observed; it is beautiful to behold, and of most beneficent purpose, for without it all vegetable and animal life would cease upon the earth. But the ultimate secret who can find out? Why the pollen should be requisite to fructification; how it should have the power thus to impart life, man has never found out, and probably will never discover. We have looked upon the renewed vernal life of the vegetable kingdom with sympathy, and in that sympathy we have invested nature with our own feelings, and she has seemed to us sensient of joy. And now, returning to ourselves, as subjects of the like process, we behold

the fruit to be not only new life, but in its consequences to be man's chief resource for all his happiness; for hence spring, the comforts and refinements that belong to the family; the love of wife and children; intellectual culture, developed affections; and the training of human souls. We have been thus led by a pleasurable instinct, and a virtuous obedience, to continue our race, and have found therein our best welfare and highest excellence. God has done this, yet has kept His secret.

But science will ever interrogate nature; does so boldly but not blamably. She will with telescope ceaselessly sweep the heavens; she will with microscope untiringly explore a boundless life that everywhere teems unseen by the naked eye; she ever applies her chemical tests and analyses as keen as the sharpened human intellect. Her researches are well rewarded; but she may not know all. For often it happens, that "Seeing ye shall see, and shall not perceive." With the microscope and scalpel the sources of life are explored, and science announces that all life, in the higher organizations, comes and is maintained by the blood propelled from the heart. Thence came the parental germs that have met and started the embryonic life; thence has come every increment that has given the body growth from the gelatinous germ to the mature man. You have traced the physical being back to nearly its starting point, and found its component parts all to have been molecules of matter, or corpuscles, or cells in the blood. These the physiologist declares to be the physical basis of life. We may not venture to deny this conclusion, for his dissections and magnified sight have revealed what he describes, and it comports with our observations. But chemical tests can but imperfectly verify his observations, for they can only be applied to matter dead, and when life has ceased to resist nature's chemistry, that chemistry is quick to change the material which had been the living source of life's supply. The assisted eye has seen in that crimson current, says Huxley, "innumerable multitudes of little, circular, discoidal bodies, or corpuscles, which float in it and give it its color, (and) a comparatively small number of colorless corpuscles, of somewhat larger size and very irregular shape." Huxley speaks of these as marvelously active, changing their form with great rapidity, as if independent organisms; and their substance he calls *protoplasm*. These he calls the units of the human body, and says: "Beast and fowl, reptile and fish, mollusk, worm and polyp, are all composed of structural units of the same character, namely, masses of protoplasm with a nucleus." "Thus it becomes clear that all living powers are cognate, and that all living forms are fundamentally of one character." Thus while Darwin would make all living beings related by descent from a common parent, Huxley would make all to be related as creatures of the same blood.

Now the only reliable basis for such conclusions seems to be the magnified vision, limitedly applied, revealing similarity of looks and activities. The elements of the universal protoplasm are stated to be "carbon, hydrogen, oxygen and nitrogen." But it is not shown or said that these

exist in the like proportion in the protoplasm of different creatures, which might explain much of the difference there is in their structure. Thus if the proportion of oxygen in the air was considerably increased, all life would be burnt up; and if the proportion of nitrogen were considerably increased in the atmosphere we breathe, all life would be extinguished.' Without much more observation than appears to have been made, science cannot insist upon the sweeping generalization Dr. Huxley has made, that all living creatures are cognate. His facts are few, and the theory deduced runs counter to the common observations of men. Likeness in the looks of the white corpuscles, without showing of what they consist, or actually do, is not proof adequate to the induction. The ova in the ovarium of living creatures, and the initiate particle that vitalizes them, may appear much alike under the microscope; but from the ovum of one comes a fish, from another a fowl, from another a beast, and from another man. It is inferable that from the germ upwards the structures of these creatures have had various elements and in differing proportions. Were it not so, creatures so diverse in form and nature, it seems not reasonable to believe, could be the result. This objection Huxley does not attempt to explain.

Again, the different kinds of food that animals live upon show that the nourishment that feeds their life, in its first vitalized stage, called by Huxley protoplasm, must vary in the nature and proportions of its elements. Some live on animal food only; others upon grasses and grain only; man upon animal food, grain and vegetables. Some can eat with impunity things poisonous to others. Some, too, secrete deadly poison from the material within them. The qualities of the things eaten or drank must enter into the circulation and growth, and these must furnish molecules or cells of qualities such as the body demands. Portions of food are to be rejected; first without entering the circulation, and afterwards through the secreting glands. The breath of the drunkard shows that alcohol has entered his circulation and is exhaled from his lungs; it is shown in the capillaries of his face; and by dissection, it is perceived in the brain. The nursing mother, who has taken medicine, transmits a portion of it to her child, by the milk secreted from her blood. Many medicines are administered with the view to their effect through the blood-circulation. These enter the vital current and produce their known effects.

The cold-blooded and warm-blooded animals, the edible and poisonous, cannot be taken to be creatures of the same substance; and though they may have been built up from a fluid circulation, it cannot reasonably be inferred that they have been composed of the same elements; and if not of the same elements, the protoplastic theory to unify life becomes baseless: "All flesh is not the same flesh."

But if the vitalized ova and protoplasm that start and build up life were homogeneous, or approximately so, only the more wonderful must be the power of the life which can construct creatures of the diversity we behold in sea, or air, or upon the land, from the same elements. From

countless globules the work is done. But each living creature is to reproduce its like, and is ever to reproduce only that; such is its mission, and it unerringly fulfills that mission. Either the life does this, or He that created the life. It is no known property of matter to produce life. And the more the elementary materials are alike, the more each life must do; the more it must rule over the materials to produce the diversified results; and the less the materials could have had mastery over them. We know well what the life appears to do, for she does all under our eyes and within us; yet she dwells herself in impenetrable mystery. What she is, and how she can carry on her operations, no man may fully know. The keenest in scrutiny are not agreed as to the import of what they see, and Dr. Huxley has not explained whence the colorless corpuscles he calls protoplasm are derived; does not say whether they are particles of food or chyle in transition to blood corpuscles, as that which is more vitalized, or whether they are derived from the latter; or whether red blood contributes any material for the construction of the body. The proportion of the colorless corpuscles to the red is less than three in one thousand (Dr. Carpenter's Physiology, sec. 15). To make the few colorless corpuscles suffice for the consummation witnessed, seems cause inadequate to the results; and is to make the vastly greater mass of red blood useless in the process, except it be merely as a tide to bear along the vital corpuscles to the places of destined use. He gives no reason why the white should be the exclusive material; or as he compares it, why the clay or brick, with which the house is to be built, is alone to be used, though that house is to contain also all other requisites to comfort: the plastering, doors, windows, floors, furniture and upholstery. It appears to be an assumption requiring proof, that the few white particles alone contribute to form and repair the different parts, the bone, muscle, tendon, tissue, etc., and contrary to different ends to be subserved, and to the universal economy of nature that does nothing uselessly. These different parts demand particles of like nature to each respectively. We know, too, that the flesh may be changed in color and quality by the material fed, as the feeders of stock well know; and this seems proof that the elements that nourish and fatten are not protoplastically the same in substance or color.

Dr. Carpenter speaks of the red corpuscles as "especially concerned in preparing *pabulum* for the nervous and muscular tissues, the former of which is distinguished by the presence of phosphorized fats, and the latter by the remarkable predominance of the potash salts; and this view derives further confirmation from the fact that a flesh diet seems to have a decided effect in the formation of red corpuscles." (Physiology, Sec. 160.) And he devotes some paragraphs to show that the colorless corpuscles are but another stage of the evolution of the red corpuscles. (Sec. 163, etc.) Again he says, "That the corpuscles, however, both red and colorless, are living cells, and that, like other cells, they possess vital endowments peculiar to themselves, is not now questioned by any one." (Ib. Sec. 196.)

We are to go deeper than a certain likeness in protoplasms, to understand so much of life as we are permitted to know. Dr. Huxley in his article entitled, "Yeast," disclaims having said anything new in his lecture upon "The Physical Basis of Life." He is, however, responsible for what he adopts, and for the breadth and length of his deductions. Protoplasm he considers the basis of life, and that it is a physical basis; and he assigns no other than this as cause of life, and makes the life but a property of the protoplasm. He says: "If the properties of water may be properly said to result from the nature and disposition of its component molecules, I can find no intelligible ground for refusing to say that the properties of protoplasm result from the nature and disposition of its molecules." Nature is deemed exuberant of one aliment, called protoplasm, that supports all the life of the world, whether received by the roots into the circulation of the trees, or by the stomach into the circulations of animals; "a unity of power or faculty; a unit of form, and a unit of *substantial composition*; does pervade the whole living world." He continues, "All the multifarious and complicated activities of man are comprehensible under three categories: either they are immediately directed towards the maintenance and development of the body, or they effect transitory changes in the relative positions of parts of the body, or they tend towards the continuance of the species. Even these manifestations of intellect, of feeling and of will, which we rightly name the higher faculties, are not excluded from the classification." "This protoplasm exhibits the phenomena of life." These extracts, and the drift of the lecture show that the author is not merely showing what is the physical basis of life, but is attempting to show that life is but a property of matter which accounts for all bodily and mental activities. He makes life a property of protoplasm; and protoplasm a thing composed of carbon, hydrogen, oxygen and nitrogen; as water is a thing composed of hydrogen and oxygen; and that as "aquosity" cannot be said to exist to produce the water from said two gases, so is "vitality" not to continue to be spoken of as something existing in the living matter, which had no representative in the non-living matter which gave rise to it. But the water is a chemical compound, and protoplasm consists of parts not chemically united; but united by that thing called life that resists chemical action; that has properties of a nature other than chemical, and is in all nature peculiar and discriminated. We see that he would thus sink the life into protoplasm, and make it and the intellect but a property of matter. But others should make better observation and induction.

It may well be asserted from all that we can observe and know, that matter cannot originate life; nor life matter. Each logically demands a Creator. Life cannot originate itself; but only continue the previously created life, by a power conferred on life to continue life. Dead matter may be vitalized and thus become part of the living body; but the life must first be, to appropriate matter for its uses, to vitalize it, and to build up the living body and to continue it in life. In all time, only life has

initiated the beings of the successive generations. We have only to consider all we know to be assured of these truths. No protoplasm could now exist, unless life had produced it. It never has been chemically or otherwise than by life produced, except as first created. It is only found in the vital current produced from dead food. The immediate cause of it there must, therefore, be the preceding vital processes, endued with power to impart life to dead matter. In this result, Dr. Carpenter considers the liver and spleen perform important service.

The interest of science and truth require that we here take a yet closer view of life's origin and perpetuation. Our love of truth and our reverence for God will preserve us from every unhallowed thought. No observation or philosophy can account for the first pair of each living species, otherwise than by the logic that all that we behold must have had a transcending Creator. Our race must have had its Adam and Eve, or first parents, ungenerated. Judging from all that observation, and science, and history can teach us, every subsequent being has had its incipient germ of life from a male parent, but only to become another life when that germ has met the prepared ovule in the mother that is to afford the offspring its nourishment and growth. It is only that seminal germ that is the incipient life, that first unites with the ovules and afterwards appropriates every other particle of matter that enters into the life of the new being. How nourished from the mother, we have noticed. In due time, but by coarser food, the man and the woman of each generation are built up to their mature perfection. But it was the life, beginning as a speck, that began and has completed the structure by employing the subservient molecular matter. The matter of itself could have taken no step in the process; it could have sent not a cell to form the growing, living structure, if the pre-existing life had not prepared that cell from matter drawn by the life-process into the life-current, and afterwards placed it where the life-builder required its service. That which was dead in the stomach took life in the blood; for the life-blood had power to impart its life to the elements it needed for the body's growth. It is true now as when Moses gave his commandments, "The blood is the life; and thou mayest not eat the life with the flesh."

Dr. Carpenter says: "After the Chyle and Lymph have began to flow into the circulating current, the *continued* generation of red corpuscles is due to the progressive metamorphosis of the corpuscles of those fluids, is an opinion that has come to be very generally received by physiologists." (Ib. Sec. 168.) "Looking, again, to the undoubted vitality of the corpuscles, and to the strong ground for regarding fibrin also as an instrument of vital force, we cannot but perceive that the life of the blood is as legitimate a phrase, and ought to carry as much meaning in it, as the life of a muscle." (Ib. Sec. 221.) "Thus then, we seem justified in the belief that the Blood, like the solid tissues, has a formative power of its own, which it exerts in the appropriation of the new material supplied to it from the food." (Ib. 222.) "There is not, in fact, a more

remarkable indication of 'the Life of the Blood,' than is afforded by its extraordinary power of self-recovery, after having undergone the excessive perversion which is consequent upon the introduction of the more potent zymotic poisons; and every philosophical physician is ready to admit that, in this *vis medicatrix naturæ*, rather than any remedial agency which it is in his power to apply, he must look for the restoration of his patient." (Ib. Sec. 232.) It is the Life that is thus potent to carry on her work; to repel injury, and to cure.

Let any one look back upon the origin of life and its perpetuation, and he must say, in the retrospect, "Between me and the first man of my race the thread of life has never been broken. I am more than link of a chain; I am part of that first life, never yet severed. As his was from God, so is mine that of an ancestry of *one continuous life*." At the inception of each generation that has preceded each of us through many thousands of years, life was but an inherited speck; but that speck was part of the next preceding life—commissioned to seize upon matter for its growth, in manner to fulfill the design of the Creator of the first life, and no other—and bound to arrest its own growth when that design should be filled out; but yet continue the nurture of the normal being until its strength should be spent by its assigned lapse of years, or sooner termination by disease, or casualty. If it has left offspring, the continuous line of life may never be broken,—as certainly it will not have been as to any survivors of the race, whoever they may be; for between them and the first parent, at any future age, their genealogy, their life, will never have been severed. But the elements of matter that have composed the bodies of the countless ancestry will have been dissipated ten thousand times, and gone the many repeated rounds of life and death; yet one continuous line of life has connected all the generations by a continuity more complete than a chain of many severed but interlocked links—by an actual physical and vital portion transmitted from every parent to every child; being as truly one continuous life, as that the planted willow slip continues the life of the parent tree.

Let not, then, the materialist persuade us that matter has done all this by matter's inherent power. The ceaseless life has done it, compelling inert matter to obey it; and thus will it use matter to carry on all the life of earth, while the world shall last. The dead matter so used could of itself exert no such power; could not initiate life; could exercise no cunning of construction; but only life can continue, carry on, and perpetuate life; so transmute dead matter to living, and make it part of that life, whose stream in humanity commenced with the first created man, and will only end with the last. All this is sure induction from boundlessly observed facts; *and reverses the theory of the materialist.* And all that life has done so wonderfully and so intelligently, it has done and ever does without a conscious will of its own. It must, therefore, do it by a will and Power that is above it, and that rules the life; the Power that gives and rules the instinct of the animal; the Power that gives the

mind of man and also rules it, except as He has conferred upon it free-will, within permitted limits.

The author of the essay on the Physical Basis of Life, carries his induction beyond animate life. He makes matter cause of life, and he places vegetable life on the same basis with the animal, and makes the like protoplasm the source of both. Both, indeed, have their circulations in which are contained material elements for growth, but elements of a quite different nature and derivation. The animal lives on organic matter; dead matter that has had life in it; the vegetable derives its supply fresh from inorganic matter in the earth or air. This leaves us justly to infer that the elements of growth are of different kinds; and if so, that there then can be no protoplasmic kindred, and nothing is gained by the theory. The fluid in the thistle and other plants have a contractility that gives movement to the circulation and diffuses the molecules or protoplasm. That shows a different impelling force from that of the heart of the animal; and rather indicates a want of identity of protoplasmic material, while the wants of the two growths demand different material. The animal's circulation constantly repeats its rounds, while the plant's growth depends upon a single fluid transmission from root to leaf, and from leaf to root, as the seasons change. Huxley would confound the two great kingdoms of nature, because there is a very limited agreement in the appearances and behavior of the fluid supply of both. Contrasting plants with the lowest animals, he says, "it may well be asked, how is one mass of non-nucleated protoplasm to be distinguished from another? Why call one 'plant,' and the other 'animal'?" The answer naturally would be because they are of different natures, showing that their protoplasm should be different in elements, and because the animal has sensation, the plant none; and usually other obvious distinctions. To call the supply of vitalized food by the same name, without proof that its elements are the same, seems to be a summary way of breaking down distinctions between the different kingdoms of beings and things of life.

Continuing our attention to vegetable life, let us judge the tree by the fruit. Can anybody imagine the resin of the evergreen to be identical with the sap of deciduous trees? The inflammable turpentine to be the same as the watery sap that would extinguish fire? Can the oak and hemlock, whose bark contains tannin, have the same base as the sap of the sugar maple and sugar cane? Can the tea and coffee trees, producing theine, come from the same elements as the palm and olive trees? The gums of commerce, the varnishes, the resins; the spices, cloves, nutmegs; the vegetable coloring matters; tobacco, opium, hashhish; and cinchonia and all vegetable drugs; it is impossible to believe that all these, and plants that produce deadly poisons, had the same base with our farinaceous food, and edible fruits. Theory that attempts to destroy these distinctions by a few observations so narrowly based as that in question, must meet with deserved incredulity, by mankind. The canon of legitimate induction is violated. A similitude of molecules presented to the vision by the micro-

scope, that tells nothing of their inherent properties or proportions, cannot determine the base of plants to be the same, when their qualities as medicines, coloring material, or nourishing food, or poisons, are infinitely varied and the opposite of each other.

This physical basis of life that is thus extended so broadly, Huxley, in a measure, defines, by saying, "that as all protoplasm is proteinaceous, or, as the white, or albumen of an egg is one of the commonest examples of a nearly pure proteine matter, we may say that all living matter is *more or less* albuminoid." Well, that may be, if sufficient latitude be allowed to the words "more or less," and yet all be as different as the things above enumerated, with many other things of contrary elements constituting their "living matter," for all that is not albumen must then be something else, and be part of the living matter that came with the albumen, or protoplasm, into the composition of the living being or thing. And this lets the theory fall to the ground. A partial similitude will not necessarily constitute identity. The theory demands too much when it requires identity of elements of growth in plants and animals of whatsoever kind.

The plant unsentient, without mind or will of its own, is said, by naturalists, to affect its *habitat*, that is, to choose where it likes to grow. This but means that it flourishes where circumstances most favor its growth, and does not elsewhere. In its life inhere wonderful mysteries that we can only refer to something above it, as we have for the life and instinct of animate beings. Its seeds are boundlessly strewn; but which shall grow and flourish, will depend upon their relative power and mastery over competing plants. This contest and its results we readily understand. But how the fibres of the roots have their gift to select from the soil only those particles of nourishment which suits the plant's growth; how the plant can convert silt into flowers; how it can send the vital current, against the law of gravitation, to the topmost branches of the oak and pine, surpasses our comprehension. We say, in part explanation of the latter, that the resin and sap pass upwards by capillary attraction, as we see water rise a limited distance in very small tubes, or through a sponge, or among the hairs of our shaving brush. This, in part, may suffice, but there must be help from vital action, as certainly there seems to be where life is employed in the fresh growth of annual plants, and the new branches of trees. The vital force must do the work, as when that is quiescent nothing is done. As in all animate nature we can only continue to look upon all vegetable life as a continuing, insoluble mystery; but of the highest beneficence. Trees and plants, ever true to the life and duty assigned them, will furnish to man, beast, fish, reptile, bird and insect, the food they require; and to man the medicines, gums, dye-stuffs, and spices he wants; and also the blossoms, flowers, and scenery he loves and enjoys with an ever-refining enjoyment. In truth, directly or indirectly, all the animate life on land, or in air or sea, is supported by the seemingly self-sustaining life of the vegetable kingdom. The latter is created that the former may live; and all, that human souls may crown the creation. Yet

all vegetable life, as all animal, now existing, judging by all we see or know, are the continuous threads of the first created life of their respective species, kept forever unbroken and unentangled.

And as every species in vegetation selects and assimilates different elements from the soil or air, and for different parts of itself, as wood, bark, leaf and flower, so does every different species of animal select those essential to its own well being, and to complete the creature that the life is busy in constructing, and it does construct, but that the parent was. These ends demand differing elements; and however seemingly alike their protoplasm and blood, those and whatever else is tributary to the varied growth and differing developments, must be equally different. It is vain for science to say to the common sense of mankind that the cells that compose the bone and cartilages, tendon and muscle, the tissue, skin, hair, all opaque, and transparent eye, are identical in material, more than in shape or function, or fruit. The sight, the tests of chemistry, commercial scrutiny and scientific classification, alike contradict the theory, and tell us it cannot be true that the protoplasm or blood of animal and vegetable, and every kind of each, can be the same. The young of the mammalia drink milk drawn from the mother: and the milk of the different kinds may look much alike, yet not be identical, and not alike be suitable to nourish the young of all. We may take leave to regard it as a myth that Romulus was suckled by a wolf; but will implicitly believe that neither "do men gather grapes of thorns, or figs of thistles."

It is of necessity that all animals and vegetables that have a vital circulation must take their food into their circulations in fluid form, that it may thereby traverse the body, and in sufficient minuteness supply its wants of growth and repair where needed. The stomach of the animal elaborates the solid into fluid; the roots of the vegetable take up the material it wants, assisted by the rains and water that gives the required transporting fluidity. But that each process sends into the circulation the same elements for animal and tree, there is not furnished the beginning of any proof, while the different natures of the growth indicate very surely that their wants are not the same, that their supplies are different, as their products are infinitely diverse. It must, therefore, be misleading to maintain the theory "that all living powers are cognate, and that all living forms are fundamentally of one character." There is yet a vegetable kingdom and an animal kingdom, and those infinitely diversified. "There *is* one flesh of man, and another of beasts."

Seems it tedious and unnecessary thus to have traveled over the grounds of this theory in so much detail? The conclusion to which it is carried shows how important it is to have carefully considered every foundation-stone of the superstructure. It concerns man the most deeply of all questions to know what he is and what he is to be. That such question is involved, is shown by the conclusion at which the theorist has arrived. In his own estimation he has proved the protoplasm of the vegetable and animal, animal including man, to be the same. Thus Professor Huxley

says: "As I have endeavored to prove to you, their protoplasm is essentially identical with, and most rapidly converted into, that of any animal, I can discover no logical halting place between the admission that such is the case, and the further concession that all *vital action* may, with equal propriety, be said to be the result of the molecular forces of *the protoplasm* which displays it: And if so, it must be true, in the same sense, and to the same extent, *that the thoughts to which I am now giving utterance, and your thoughts regarding them, are the expression of molecular changes in that matter of life which is the source of our other vital phenomena.*" Is there anything of uncertain sound in this? He expects from it the outcry of "gross and brutal materialism;" and then confesses that "*most undoubtedly the terms of the proposition are distinctly materialistic.*" What more he next says, I will show hereafter.

Thus the logical climax of the theory, the capstone of the edifice, appears to be that the thoughts and mind of man, being derived from the same protoplasmic source as the lower animals and the plant, and the physical organization being thence built up, it is consequently to follow, that when the life of this body shall be dead, there will be no mind, no soul, to survive; that it can only with truth then be said, "the bubble of life has burst!" Such would be the natural conclusion of mankind from such premises. And if such be the import of human life, what then is the worth of creation! Must the dignity of man, and the glory of the universe, and the exalting faith of the immortality of the soul be thus cast down, and shorn of their grandeur, and of their logical significance, because the works of the Almighty show some faint resemblances in the early processes of life? That because He makes matter subservient to life, and life to the mind or soul, that, therefore, all must be matter, and all but matter? If such be the logic of creation, as only now found out by very limited applications of the microscope, it would seem to be wise in us to wait a thousandfold further applicatious of that instrument to the invisible elements of life; and not the while refuse to use our eyes and the telescope as to what they can see, and also to use our understanding and its logic as to what they can clearly know, before we surrender our faith in all that humanity, in its best conditions through the centuries of time, has taken to be the import of our being and the meaning of the universe.

Happily, however, for our relief, so far as his authority will avail, Dr. Huxley makes the admission that, while he is logically carried to a materialistic conclusion by his philosophy, he is, in truth, no materialist, and that materialization would "paralyze the energies and destroy the beauty of life." He has perceived within himself a nobler sense of the import of his being, that arrests his individual conclusion, and deflects his logic, so confidently asserted, into an opposite direction. That is well, and some comfort; but may we take his mere opinion as adequate counterpoise to a theory he has advocated with elaborate detail and apparent earnestness of conviction? Those who love skepticism will continue to abide by his theory, which he has not himself controverted.

In one half paragraph he confesses to a contradiction—to two opposite conclusions: that the theory he has announced as logically true, he himself does not believe! Thus he says: "And, most undoubtedly, the terms of the propositions are distinctly materialistic. Nevertheless, two things are certain: the one, that I hold the statements to be substantially true; the other, that I, individually, am no materialist, but, on the contrary, believe materialism to involve grave philosophical error." Dr. Huxley has not said this to accommodate himself to the orthodox opinion of men. He who takes occasion frequently to encounter and brave that opinion cannot thus have insincerely conformed to it. He is obviously too candid and too brave for that. He seems in all his conduct to follow what he takes to be the truth, fearless of consequences. But what, then, must be our judgment of him? Can it be other than this: that he is possessed of a truer logic, based upon vastly more facts than the few embraced in his protoplastic theory; and that his individual belief, for which he has not given us the grounds, contains the actual truth; and that, consequently, we have Huxley's authority to condemn emphatically Huxley's theory, built upon "the Physical Basis of Life." But who will answer for his insincerity to the truth of science? For the consequences of the infidelity he has preached in his sermon? He proposes to conduct his hearers out of the slough, into which he confesses he had plunged them, and meant to plunge them; but we read on to the end of the discourse in the vain expectation of finding the stepping-stones that would conduct us out of the slough to the firm land. Does he not in this trifle with his own and the understandings of men? His philosophical speculation is one thing; his individual opinion is another. He describes no mitigated materialism that represents his own conviction. That which he has explained makes his uttered thoughts but matter; for these, he says, "are the molecular changes of that matter of life which is the source of our other vital phenomena." And this is his hopeful and confident assertion: "And as surely as every future grows out of past and present, so will the physiology of the future extend the realm of matter and law, until it is co-extensive with knowledge, with feeling, and with action." Thus the science of the physical basis of life is to absorb the mental and emotional, and make all one, all physical;—all to have but a physical basis and a physical consummation. And yet, again, he confesses to two hopeful beliefs, but flagrantly at variance with his pretension for physiology: "The first, that the order of nature is ascertainable by our faculties to an extent which is practically unlimited; the second, that our volition counts for something as a condition of the course of events." Yet neither of these could, logically, be a true belief, if man be but the product of matter and law, and these be taken as sole sources of his knowledge, feeling, and action; for all would yet be fatalism as well as paralyzing materialism. Indeed, there could be no thought, if all were matter. Mere changes of molecular matter could not be means to expand our knowledge, or rule the course of human events. What would it be to the world and its events, that the material of my brain had un-

dergone molecular change? Thoughts are not material growths; are not buds or sprouts; are not protuberances or indentations, or engraved lines; or secretions or excretions of matter, or the shifting of any molecular living particles, by any testimony ever presented to the human mind. Men cannot conceive that matter can be thought, or thought matter; and all its phenomena declare it unlike all else in created nature, and without element of matter. The mind of man has, indeed, a likeness unto God.

Dr. Huxley says, "the fundamental doctrines of materialism, like those of spiritualism, and most other 'isms,' lie outside the limits of philosophical inquiry;" says, "it is also in strictness true, that we know nothing about the composition of any body whatever as it is." But is not all knowledge within the limits of philosophical inquiry? And, though we cannot know how matter, or life, or mind can be, or what in essence they are, yet we certainly can and do know much of the properties and actions of each and all of them, and of their differences from each other. We must not become so far positivists as to refuse to know all that is knowable; and especially may we not ignore the human mind. It is our duty to search after all attainable truths, and when we have come to the limit of our faculties, there reverently to pause, in the presence of an infinity of knowledge known only to God. To seek knowledge only of things physical, and things of life, and there to set the limit of inquiry, seems but the prudery of scientific caution, that can win no credit for wisdom, nor increase our trust in the authority of the teacher.

In this discourse we have assumed that, in its origin, life had a Creator, upon the logic that such effect must have an adequate and a far-transcending cause. As matter and life logically demanded a Creator of each, and neither produced the other, so does the mind or soul, by even higher claim, logically demand a Heavenly Father. Its nature is too distinguishable and transcending to be confounded with matter or life. Life dominates matter, mind dominates them both, and God them all. The soul asserts a higher than a generated parentage, and a large immunity from the mutations of matter. Matter ever slides from under mind, but its integrity is untouched. The matter that has sustained the life of one as old as the writer, has wholly passed away from his body more than ten times; and the more rapidly changing parts have been eliminated with vastly greater frequency. Yet the mind in this body has a memory of conscious identity from the year next before the first of the current century. Such imperishable mind can have no element of ever-shifting matter in it; and must be a being of different origin and nature, both from the material of this body and the life of this body. That material is ever changing, and is often renewed, until the body's death; and when the life that maintained the organization shall have succumbed, and have ceased to exist, except as it has been continued in a living progeny, we justly infer that the mind, or soul will outlive the organization and the life, and will return to its Giver, to share His pleasure, or meet His

condemnation, as deserving. This is inferred from what we know of the nature of mind, and the induction that creation must have an adequate significance. The great truths of Scripture are inductively reattested by the truths of philosophy.

Thus, then, stands the phenomenon of our being. The matter that enters the body may be, in itself, for all we know, imperishable, but is certainly transient in each living body; remains there until effete, and is then dismissed by the vital process; or at death passes into vapor and ashes, and enters the further rounds of chemical change and vegetable and animal growths. The organized being of one generation of the life of an unbroken continuity from the first parents has come to an end, except as continued by offspring; but the individual, ungenerated, immaterial mind, that was neither the matter nor life of the body, lives on forever.

We have seen the life assert a dominating power over all the material that has built up the organized body. This life process is essentially one independent of the mental will. During gestation this is plainly so; and is so through life, except as the mind has power to refuse to conform to the laws of health, and may mar life's healthful functions and duration, even to the perpetration of suicide. The circulation, digestion, assimilation, and eliminations go on in health almost without our consciousness; but we are compelled at intervals, by hunger and thirst, to keep up the needed supply of food and drink. The brain and nervous system are also thus nourished, as the rest of the body,—though it is the system especially subjected to the instant dominion of the mind or will. The material brain and nerves are not the mind, nor do they produce it, but are servants of the mind. Mind is other than the brain and nerves, and is other than the life: and it alone can rule, and must give account of itself,—the body, and the life. The vegetable carries on all its given life-processes, without sensation and without mind. The animal below man does the same, except as it has a limited mental development that we call instinct; has also, limitedly, brain and nerves, and senses; all of wonderful fitness for its preservation, which we may not now pause to consider. The life of plant or animal will grow to its assigned limit; will cure its own wounds, and reproduce its kind; but is other than the instinct of the animal, yet more remote from the mind of man: it alone, of all beings, has moral responsibility.

Among the hundred or thousand wonders of the life, whose causa explanation can be in Deity alone, and over which mind had no formative power, is the fact that every kind of nerve has been fitted for its special duty, and can perform no other. There is, in this, admirable design to prevent confusion. The nerve of sense can give sensation to, but can impart no mandate from the mind. The nerves that execute command will give back no sensation. One of each is attached to each serving muscle, but neither can do the appointed work of the other. The nerves of sight, hearing, taste, and smell, can neither of them perform the func-

tion of any other. The brain, the commonly supposed seat of all feeling, has in itself no feeling. Sir Charles Bell says: "The brain is as insensible as the leather of our shoe; that the brain may be touched, or a portion of it cut off, without interrupting the patient in the sentence he is uttering." The brain and the sensitively perceiving mind must, therefore, be different. The one is cut away; the other suffers thereby no interruption of thought or its expression. One feels; the other does not. One commands; the other obeys. The muscle is moved by the will and exerts great power, but through a brain and a nerve without muscle, or physical power, so far as is seen. Apparently an immaterial mind says to every muscle, do this; and it doeth it, but by the word of command. Truly, the body, life and mind, each, is very wonderful, and most wonderful is their combination; a combination of dissimilar things, made to act in antagonism, and yet bound to act in harmony, for the welfare of all. Awake, the mind is to regulate all for the common good, yet may not, without injury, much interfere with the life-process of the bodily organization. Asleep, the physical reacts, taking a limited advantage of the unwatchful mind that has let drop the rein of discipline. The mind, in the semi-consciousness of dreams, ranges through bright scenes and beautiful images, if all be well with mind and body; but if either be unhappy or disordered, a dark change comes over the happy dream, and then threatened dangers and startling incidents awake the mind to resume its discipline; happy then to find its troublous adventures "but a dream." Yet, in the sleeping and waking experience, the mind and body have acted and reacted, both as united, and often as opposing powers.

The materialist sometimes ventures even to liken life to a process of crystallization or chemistry, or mechanism, and mind as well. Crystallization follows one law, and, the world over, does one thing, and forms its crystals and gems of each kind on the same angle; her ultimate particles of the same kind being of the same shape, and obeying one law of attraction. The chemical affinities act under laws as certain, and under the same circumstances act always in the same way. Living things are more complicate; and the process of growth is carried on by an apparent choice as to the selection of material and in the deposit of different particles, for the growth of the several parts, differently from crystallization and chemistry. Life is not molecular, or magnetic, or chemical attraction; but is a vital process that employs various materials; utilizes them, and disposes of them differently to perfect the common economy. It employs, it is true, chemical processes in breathing, etc.; and in the heart, eye and ear, and in the action of the muscles, mechanical structures and powers; but all is moved by and independent upon the life that has made from matter living molecules, and with them constructed the creature. But all this, though subservient to, gives no explanation of, the mind: shows no kindred to it; gives no information why we have consciousness, how we can feel and think. No proof is offered, nor can, it is believed, be adduced, to show that the mental action consists in but physical changes. The

brain, as the arm, may show weariness when overtasked by the mind; may suffer waste of material, of phosphorus, if you please; but that will not prove mind to be brain, or brain mind.

The all-transcending importance of this subject demands our yet further patient consideration. On the discrimination of the mind of man from the body and from the life, depends our truthful apprehension of the great problem of what we are, and what we are intended to be,—the most important consideration that can occupy the human mind. Can we, as rational beings, live over threescore years and ten, or more, and not devote much of our time to reflect upon this subject, the highest of philosophical studies? This is not an "ism" lying outside philosophical inquiry. No religion can begin her task, no philosophy can consummate her study, that has not persistently dwelt upon it and made it the theme of habitual thought. It is the necessary climax of all the study that can give us the solution of the problem of the universe. In this age of materialistic skepticism, that respects no time-honored opinions, or sacred traditions, we must begin where the physicists begin, but may not stop where they are wont to stop; may not refuse to know the ultimate significance of all created things and beings, body and soul, as they are constantly presented before our senses, and demand interpretation from our reasoning intellect. We may not fail to examine and consider all the true facts that the naturalist and physicist make the basis of their theories, nor all other facts that must be taken into view, for a true solution of the problem. No *a priori* assumptions may be admitted as bases of induction; and it must not be allowed the skeptic to say, as he is sure to do, that he only builds truly upon certain facts; that his faith alone stands in inductive truth; that religious faith will not bear the test of induction from ascertained facts. And we must not permit him to make his inductions from less than half the facts that define our being, and these the less important.

The mind's thoughts are not propagated as things of physical growth. We but borrow, in relation to the mind, the language of the garden, and use it figuratively, when we speak of sowing mental seeds, or propagating ideas. The thoughts I am speaking, I do not lose; and your gain, if any, is not a material acquisition; nor, so far as you or I can ever know, has the effect been produced by molecular changes in our brains; and if such changes do take place, they are a life process of the brain, and cannot, conceivably to us, be the thoughts that enter into and exercise your minds; thoughts that, as believed worthy, or as your minds may make them worthy, may become permanently your thoughts, after the molecular particles moved, if any such, will have long passed away. The mind may, indeed, for aught we know, and we may so conjecture it probable, put the brain in motion, as we know it will thrill the nerves, and can hurry the blood; as the wind can heave the water into waves, but the cause and the effect are different, and continue ever after as distinct as before.

Physiology teaches us that the mind is seated in the brain; for with the

brain is connected every nerve that gives to the mind the sensations received by it; and with the brain is connected every nerve that executes the will of the mind upon every muscle of the body movable by the will. A ligature round the nerves of sensation will prevent the mind receiving sensations by them from a point beyond the ligature; a ligature round the nerves that obey the will, will paralyze its power to command the muscle to which the nerve is attached. The perception and command are intercepted at the ligature; and beyond mental power has ceased. The mind, that is the light of our being, sits enthroned in a chamber of life-long darkness, cushioned upon medullary matter; moved by no muscle, yet moving every motor muscle as bid to obey its will. The eyes are called its windows; but that is to speak figuratively, for no ray of light ever enters there; the senses are called its portals, through which we learn all we know of things without us, but no sense ever lets into the mind one particle of matter.

We have seen that the life of the body is fed by material food taken into the stomach. The mind is not so fed, nor fed by any material food. The mind, or a mental capacity, exists in a child at birth, underived from sensations, for it must pre-exist to receive the first as all after sensations. Though we may not know how it can exist; of its nature and operations we can observe and know as much as of matter and life; and we have no more right to refuse to know all that we can understand of it than of them. It is the nobler part of our being, and that which is most characteristic and most prophetic of the purpose of existence.

The immaterial mind is fed but with immaterial food. It draws this from sensations without and within; and thus learns the nature and qualities of all perceived things. It digests that it receives; forms conceptions or ideas by its inherent power; has capacity of comparing, thinking and judging, and thus is also self-fed from within by immaterial thoughts as no life is fed. Thus we may observe the mind to be developed; the mind that can frame the constitutions and laws that preserve human society, and that can administer them; that can wield the physical arms and resources of the nation; and can develop the truths of philosophy and religion. All this is done by thought, only by thought; by thought, indeed, sometimes inspired; and the quieter the body and the brain, the more surely truthful is the mental judgment and the might of its power.

Now let us consider some of the sensations that the mind notices as perceptions and conceptions, and stores as ideas, to be used in thought and judgment, and see if they own a material source. The eye opens upon all visible things, and by a lens the picture of them is represented on the retina, or back part of the globe of the eye; a picture the reverse of that in the outside world, upside down, right side left. The retina is the expansion of the optic nerve leading to the brain, that gives to the mind a perception and conception of the image on the retina; not that the image can itself be taken through the round opaque tubular nerve; not that there is any material picture on the retina, any more than the reflection from the mirror is a real picture on its surface: but the mind has capacity

to reach forward and take perception of the picture truthfully, but takes it restored from its reversals by the convex lens to its true position, as was the outside reality; up-side up, and right-side right, as is at once verified by the outreached hand. This power of perception is something more, and quite different from, the materially-fed animal or tree. There is no protoplasm here. The perceptions, and the ideas thus derived through all the several senses, are alike immaterial. Through the eye, the ear, the touch, taste, or smell, it is not perceptible, nor conceivable, that outside matter enters into the brain, yet less into the perceiving mind. It seems more reasonable to infer that the mind, which by its will can command and put in action the many muscles of the body, through the nerves of command that extend from the brain to them, can also reach through the distinct system of the nerves of sensation, wheresoever impinged upon, and take note of all sensation. Thus doing, the mind is filled with perceptions, conceptions, ideas. But when it perceives, thinks, compares its ideas, recalls its memories of long past years, forms new judgments, and the will sends forth its mandates, we are not to believe it is carrying on material operations, before the muscles have acted; that thoughts are the bubblings or heavings of medullary matter; or as electricity they are elicited by material friction; or as the chemical corrosions of a battery; or are any other material production. There appears no evidence of any such processes, and these indicate no relationship with mental action. The memory of half a century ago cannot be a recalling of the matter of the brain of that time: the perceptions taken into the mind contained no material element, and the mind's elaborations of immaterial perception cannot be elaborations of matter, or produce material thoughts. Thought that ranges instantly over creation cannot be bound by the limitations of matter. Whatsoever is matter must have the bounds of matter; matter must have the properties of matter. Thoughts are not so subject. It is not in the nature of matter to range beyond itself; to look to the past or future, or in imagination to survey the world and universe, and all that in them is. It is not in the nature of thought to be subjected to mechanical or chemical tests. If thoughts be but matter, they must be eliminated by the body's ever busy absorbents as waste material, and there could be no memory of them; but the mind holds not her rich treasures by so slight a tenure. The intellect would then sit upon a throne whose base would be incessantly undermined; nay, be rapidly swept away, since the new tissue supplied to the brain by the life-process would not replace the lost ideas. Immaterial thoughts, the immortal mind, is not carried off as waste and effete matter; as sewage through the sewers of the body. Newly-deposited brain tissue from the blood would not restore thought that has vanished. Memories are not as characters written on the sand, to be washed out by ever refluent waves. The memories of a well-preserved old man, whose strength has not failed, nor his eye grown dim, make him a being compounded of the characters of three generations; with mind informed by the pressures and knowledge of

them all; with gathered experiences and forethought that make him largely prophetic of the future. So the poet's vision has seen and described such an octogenarian; or knew him, and sketched him from life:

"Age had not tamed his eye: that, under brows
Shaggy and grey, had meanings which it brought
From years of youth; which, like a Being made
Of many Beings, he had wondrous skill
To blend with knowledge of the years to come:
Human; or such as lie beyond the grave."

—*Wordsworth.*

As the visual picture entered not the brain, so will not the vibrations of sounds in the air. The speaker's mind is filled with thoughts which he is earnest to inculcate upon his hearers, and vocally he gives them to his thousand listeners. I do not say *transfers* them, for he has not parted with one idea, though they have got all he has spoken. No phosphorus, or any other matter has left his to go into their minds. His voice has but made vibrations in the elastic air, which otherwise has been unchanged. These vibrations have spread concentrically from their centre, with their ten thousand distinctions of modulated words. These sounds have reached the ears of the listeners, and their perceptive minds have reached forward through the auditory nerve, whose extension by delicate fibres floating in the water of the vestibule of the ear have been stirred, and given to the mind the perception of every variation of the voice of the speaker; of its formed words, its inflections, cadences; its tones of earnest pathos and its joyous or sad emotions; and all its varied meanings. But no vibration of the air has reached the interior of the brain; indeed, no material idea had traversed the air to reach the hearers. Air-borne wavelets of words, or conventional signs of ideas expressed only by distinctions in sounds, have reached the easily moved hairy fibres of the auditory nerve, and imparted motion to them; but there the material motion has ended, yet the perceptive mind has caught the many distinctive meanings. But no motion, no sound, no matter, has entered the brain by the auditory nerve; for the nerve there embedded is constricted in passing through a narrow orifice in the skull; is not itself floated, or tensioned, to transmit vibratory motion; but cut off from the air, the vibrations of which have been spent upon the drum of the ear and the wonderful apparatus, and water within the vestibule; and were this not so the vibrations of the air are not transmissions of matter; but when the voice has sounded, the air and the ear are again as if no voice had spoken. The mind has taken the perception of the distinctions of sound from the fibrous extension of the auditory nerve. Had the same words, or conventional representations of thoughts, been written or printed, and then been read by others, these would have received their characters pictured on the retina, without the charms of vocal expression, and alike without the reception of any material element in the brain.

It is obviously the same as to the sense of touch. The finger will give the perception of the shape, density, temperature, etc., of the object

touched, but no matter or thing will be transmitted into the brain. The mind, by its perceptive power in the brain and nerve, will have taken notice of the properties of the object, and formed an idea of it. By no sense has the brain or mind been materially fed. Here we should recollect the physical condition of the brain. It fills the chamber of the skull; is always dark, is always silent. Therein is the source of all the intellectual light in the world, yet not one real spark, or beam of light has there ever glowed. No ray of light can depict a picture therein; no vibration can carry a sound within it; no tasted food, or touched thing, nor aroma of incense, can enter there. But the nerve of each sense has been affected by an outward object, and the perceptive mind has reached to notice the action of the outward thing upon the nerve. In the eye it is a picture thrown by the light on the retina and it is there perceived; in the ear vibrations have stirred the floating fibrous extension of the auditory nerve, and there they have been perceived with their varied distinctions; and by the other nerves of smell, touch and taste, the perception has been at the point of contact. The mind's command reaches by the motor nerve to the remotest muscle: sensation by touch may reach as far; and there appears to be no reason why the mental perception has not reached to the point whence such sensation is said to have come. The mind wills to move the toe, and it has at the same instant the perception that it has moved. Indeed, each nerve of sensation has its local duty to inform the mind instantly of every impingement upon the surface over which its fibres are spread. This it can only do by the mind's taking notice of it, so that sensation implies perception. The nerves at the stump of an amputated leg, when irritated there gives the perception as at the foot or toe to which the nerve when unsevered had been attached, for that had been its established duty in its relation with the mind; and the perceptive mind yet adheres to its original consciousness, and still takes its perception as from a living foot, where now there is none. The perception that had formerly reached the extremity of a perfect nerve comes to consciousness as from that point, though the nerve has been touched midway. And when the optic nerve is involved by disease, its illusive visions produced by disease, appear as they would, if truly pictured on the retina; and so if the auditory nerve be so involved, the illusive sounds appear to enter the ear. And so, too, as to those bright visions and hymning tones by which the dying are often preternaturally visited, showing them, in advance, celestial scenes and companionships such as they are about to enter, their outward senses seem to them still to have served them, and they wonder that their surrounding friends have not seen and heard all that they have so intensely enjoyed: but no outward sense had seen or heard all that the mind had directly perceived. The appropriate nerve always ministers to the mind according to its original appointment, and responds as the faithful sentinel, only from the assigned post of duty, and there it is that report is made to perception. Sensation and perception appear to be synonymous and simultaneous, and at the same point; but the conception of ideas, and the mental processes of thinking, comparing, imagin-

ing, judging and willing, are carried on in the superior brain, by which man is distinguished above all other creatures. Physiologists speak of the sensorium or central ganglia, below the cerebrum, as the common centre of sensation; but our own consciousnes when thinking, and our pernal headaches for over-much thinking, plainly say to us that the crowning and frontal hemispheres of the brain are the seat of thought and mind. It is the mind in that little space that rules the world.

The reflective anatomist as well as others, is struck with wonder when contemplating the human brain as the seat of thought and sovereign will: yet as poet he must speak figuratively. He exclaims as he looks upon it,

> "Then mark the cloven sphere that holds
> All thought in its mysterious folds:
> That feels sensation's faintest thrill
> And flashes forth the sovereign will:
> Think on the stormy world that dwells
> Locked in its dim and clustering cells!
> The lightning gleams of power it sheds
> Along its hollow glassy threads!"
>
> —*Dr. O. W. Holmes.*

Such combination of body, life, mind and feeling, are indeed, more wonderful than miracle, and justify the anatomist and poet in his prayerful conclusion:

> "O Father! grant Thy love divine
> To make these mystic temples thine."—*Ib.*

The great fact is never to be forgotten, that the body is fed only by material food; that the brain and the nerves are also fed as the residue of the body from the living blood; but that the mind is ever and only can be fed by immaterial perceptions of outward and inward material things, and as it is self-fed by its own immaterial thoughts and inherent emotions. How amply the physical brain is fed by the blood, is apparent when physiologists tell us, that its proportion to the whole body is as one to thirty-six, while one-fifth of the whole volume of blood is in circulation there.

There is another test we may also daily observe in others and in ourselves, showing that mind and body are not alike nourished, namely, that the gross feeding that expands the body, does not enlarge, but obscures the mind. That the mind is usually clearest and most effective when men are abstemious and temperate, provided only they eat enough to keep up their normal strength. Many bright minds that have enlightened the world, would never have been its shining lights, had not their bodies been frail and their physical organization delicate; indicating, not that the body and mind were one, but that the body's grossness had not overlaid or obstructed the free thinking and reasoning mind.

The power of mental consciousness and his capacity to think, constitute man's great distinction. Mind makes him man, and lifts him above all other creation. It is the mind that yields him all his purest and truest pleasures. We say that the eye sees, and the ear hears. These senses are but inlets to outward sights and harmonies: it is only the mind that per-

ceives and enjoys. The transporting prospect we look upon; the landscape of lawn, trees, river and mountain; or the music that charms us with indefinable delight, are pleasures inherent in the mind, inborn of the soul. Led by the great dramatist, we willingly say with him,

> "Here will we sit, and let the sounds of music
> Creep into our ears: Soft stillness and the night
> Become the touches of sweet harmony!"
> "Such harmony is in immortal souls."

And such inner sense of the beautiful: our moral sense; our sympathy with our fellow beings; our emotions in worship; "our sense of an endless being;" are all inborn of the soul, and assure us ours is the harmony of "immortal souls." Necker, statesman of France, also reassures us of what Shakespeare so beautifully said: "The whisper of the gales, the murmur of waters, the peaceful agitation of trees and shrubs, would concur to engage our minds, and affect our souls with tenderness, if our thoughts were elevated to one Universal Cause." It is thus in thought and emotion that alone we can rise to commune with our higher self, with the highest endowments of our friends, and with Deity.

The materialist supposes he has advanced his theory when he tells us, that it has been found, after a speaker has used extraordinary mental exertions, an analysis of his urine shows an increase of phosphorus; and this is inferred to be a material residuum of the speaker's spent thoughts! The idea must be that phosphorus is the matter most likely to be mind. Let us apply another test, not material, to this supposed experiment: the scrutiny of the thinking mind itself. The exertions of the speaker were probably much more physical than mental, and the result, if true, would be more properly assignable to physical causes. The ideas of the speaker are commonly formed in advance, in his study, in quietude, and the best of them in the wakeful hours of the night, when the body is in perfect repose. The delivery of them so far as the intellect is tasked, is more the easy exercise of memory than the formation of new ideas. But to make the delivery of them impressive, the orator exerts his voice; gives violent play to the lungs; uses earnest gesture; accelerates the circulation; produces perspiration; and it would be an obvious consequence, even if there were no increase of the phosphoric deposit, that as much of the water in the blood has gone out through the pores of the skin, which would otherwise have diluted the urine, that the phosphorus appearing in it is found in larger proportion.

Though matter be essential to the growth and transmission of all life though matter and life be essential to sustain the mind in its manifestations in this world: all these three are of very distinctive nature. In the plant there is life, but no brain or nerves, nor feeling or mind. These, therefore, are not necessary to the phenomenon of life. It is the nourished blood of other composition than vegetable protoplasm that must flow and bear the life-sustaining material of the animate being, and that for brain and nerves as well as the residue of the body. You may intercept the mind's perception, and life will go on: but intercept the blood's circula

tion and the excluded part is killed. Sir T. C. Morgan, M. D., says: "If the supply of blood be cut off from a limb, by means of ligatures made upon its arteries, sensibility of all kinds is in a very short time extinguished; and the part dies, and undergoes the same changes, as supervene on the death of the whole body." "If, on the contrary, the circulation continue uninterrupted, and the ligature be cast round the nerves of the limb, so as to cut off its communication with the cerebral centre, the other tissues will continue their functions uninterrupted by the accident." "These counter-experiments clearly demonstrate that the nervous system is not the fountain of life to the rest of the economy; but receives its animation, in common with all other tissues, from the action between its own vessels and the circulating fluids." (Philosophy of Life, 217.) Thus the incomprehensible life requires matter as the vehicle of its manifestations; and the incomprehensible mind requires matter, including brain and nerves, as well as the life, for its manifestations: but the distinctly manifested actions of both are full of diversities and contrarieties. As life cannot account for and produce matter, nor matter life; so do neither, or both together, account for, or produce mind, but only subserve it. For each the Cause can only be logically sought in a Creator; and for their wonderful combination, and concurring, or counter-actions, in the being man, we can, in reason, only refer ourselves to Him who transcends all and knows all, even the thoughts and mind of man. That mind that is not matter nor the life, but is above these; that has no likeness on earth; proves itself of all we know the most like unto God who is a spirit. It alone in nature reviews its own consciousness, as under an inevitable sense of moral and religious duty and accountability, and asks and answers the question, "My soul, is it well with thee?" If there be another such being in the universe, it can only be an angel in heaven.

Xavier Bichat, who studied and wrote at the end of the last century, and until the second year of this, and had much experience in surgical practice during the French Revolution, was certainly the profoundest physiologist of his day. He did not fail to perceive that the human mind was something different and higher than the brain and the nerves, which he regarded as but material instruments of the mind. He considered a want of harmony in the two superior hemispheres of the brain as cause of imperfect perception, not by the brain, but by the mind or soul, saying, "for the brain is to the soul what the senses are to the brain; it transmits to the soul the impressions conveyed to it by the senses, as the senses convey to the brain the impressions made upon them by external objects." (On Life and Death, 30–31.) "If both (the hemispheres) do not act alike, the perception of the mind, which ought to be the result of the two sensations united, will be inexact and irregular." (p. 31.) He inquires, whence arises the facility which our sensations have of undergoing so many modifications, and answers: "To conceive of it, let us first remark that the centre of these revolutions of pleasure, of pain, and indifference, is by no means seated in the organs, which receive or transmit the sensation, but in the soul." (Ib. 49.) Thus imperfect perception and

apprehension, and, indeed, imperfect intellectual powers come from defects in the material instruments that serve it; but it is to be said that the defective structure produces deficient mind only in the sense that it has served the mind with imperfect perceptions, and hence with erroneous conceptions for its use. The nature of the mind may thus be the same in all, though furnished with perceptions and ideas, and exercised and developed, as variously as the number of human beings. Then, again, the physical constitution and the animal passions, as well as the emotions and effections, social, moral and religious, will also differently affect the sensations, perceptions, and powers of reasoning; our thoughts, imaginations, judgment and character, and yet not be the mind that thinks, reasons, judges, and acts. They are most important parts of the being; but the physical can be no part of the mind.

Yet Mr. Huxley tells us that our thoughts "are the expression of molecular changes in that matter of life which is the source of our other vital phenomena;" but he states no reason why this should be so; why matter or life, separately or together, should produce thoughts. He takes no notice of their contrary nature and operations from matter. Now, as we have seen, the process of life gives its own proofs, immeasurably surpassing in accuracy that of the microscope, as to all that enters into the composition of the plant or animal, as attested by products infinitely varied, and thereby has proved all protoplasms not to be *bases* of the same nature, and that life uses other elements in her structures; so the different natures and actions of thoughts and mind from life and matter, must be taken as proof that they are not one with, nor can be produced by matter, or yet be the life that has subjected matter to her uses. The life, instead of producing mind, is made subject to the mind; as to its uses, what it shall be: whether it be more worthless than the festering charnel heap, or in purity, perfection, beauty, and glory, it shall be the fitting companion of immortal immaculate beings.

Professor John Tyndall, always ardent and hopeful in scientific discovery, does not leave the materialist without hope in the future, yet does state this: "I do not think he is entitled to say that his molecular groupings and his molecular motions *explain* everything; in reality they explain nothing." "The problem of the connection of body and soul is as insoluble in its modern form as it was in the prescientific ages." "The passage from the physics of the brain to the corresponding facts of consciousness is unthinkable." (Fragments of Science, 119.) True, the manner of the connection is unthinkable, but the fact of such connection between very dissimilar things, all must admit who do not deny the evidences of their senses, the proofs of experiment, and of the mind's testimony unto itself; and the higher significance of mind and emotion seems equally obvious.

The mind is placed in closest alliance with the body, but is of different constituency and power. Set over the body to rule it, her throne is in the brain, whither the nerves of sensation are ever giving information from without and within; whence her judgments are ever issued, and executed through the nerves of command. Would you liken this to the telegraph?

—you must carry the comparison to include both operator and sender of messages; must note that in the centre is the mind that thinks, and that receives, and sends the messages, and commands and executes as well. There is still the mastery of mind, ever asserting her power over matter, and her own likeness unto God. And though so small a speck, there is nothing known to man that will so bear to be put in comparison with our conception of Deity, who is a spirit, as the immaterial mind of man.

It is not to be doubted, after the experiments and observations of Prof. Matteucci and Drs. Du Bois-Reymond, Carpenter and Radcliffe, that electricity pervades the nerves and muscles of the body; the precise service of which awaits further development, but is supposed to be identified with the ordinary force and action of the nerve and muscle. Dr. Radcliffe says, as the result of his investigations, "There is reason to believe that all kinds of electricity act upon nerve and muscle by way of charge and discharge, the charge antagonizing, the discharge permitting, the state of action." Whatever may be further ascertained as to the agency of electricity in the animal economy, of this we may be assured, that it will act subserviently to life and to the will. So it is found in the electrical eel and the torpedo fish, in which life largely accumulates it, and the will discharges it upon an enemy, in electric shocks, but only so long as the supply lasts, when the belligerent thus armed must await renewal of supply by natural recuperation. With all animate creatures rest after fatigue is the appointed means for renewal of strength to muscle and nerve, to become fitter instruments of the will; and that is to say, after the exacting will has ceased to enforce wasteful action, the life process works on during repose to restore the strength, and the more perfectly if we sleep. The strength or electricity would not be given us without the life gave it, and neither is to be identified with the life, or mind, or will.

I suppose there are few of active mind who have not the consciousness, when going to sleep, of those sudden nervous throbs that tell us that a disturbed electricity is seeking its equilibrium in the body, and thus several times defeating the desire to sleep. This occurs at the moment of obliviousness; showing that the mind had until then restrained electrical action; but which ensues as a physical action in the body, as soon as the mind ceases to rule. Many materials concur to build the human temple and to subserve the life. The blood alone has its more than dozen elements; its water, albumen, fibrin, sodium, lime, magnesia, iron, &c.; and heat and electricity may warm the body, and aid the vital functions, yet be not mind.

And our minds

> "Are not wholly brain,
> Magnetic mockeries;" * * *
>
> "Not only cunning casts in clay:
> Let science prove we are, and then
> What matters science unto men?"
>
> —*Tennyson.*

Prove man is worthless, then is science worthless all.

One so practical and learned as Dr. Carpenter, and so fully informed upon the results of modern scientific investigation, and himself writing as a life-long teacher of physiology, regards the brain as the instrument

of mind other than itself. "The physiologist knows full well, that the immediate operation of the will is not upon the muscle but upon the brain." "We have not only evidence of the excitement of nerve-force by mental agency; the converse is equally true, mental activity being excited by nerve-force." And he proceeds to say, "it is obvious that the view here taken does not in the least militate against the idea, that mind may have an existence altogether independent of the material body through which it thus manifests itself." "In the control and direction which the will has the power of exerting over the course of the thoughts, we have the evidence of a new and independent power, which is opposed in its very nature to all the automatic tendencies, and which accordingly as it is habitually exerted, tends to render the individual a *free agent*." (Physiology, Secs. 585, 586, 588.)

The capacity of the body is limited. Its growth cannot be forced. It can add not a cubit to its stature. But no limits can be assigned to the acquisitions of the mind. While he has life, man may learn. True, students, ardent and ambitious, will often sacrifice their lives in the pursuit of knowledge: but that is not because the mind has taken into itself more than it will hold, but more rapidly than the frail body will bear, and in manner violating the laws of health: those laws that require the exercise of the muscles, the play of the lungs in breathing fresh air, and an accelerated movement of the circulations, of the assimilative process, and of all life's functions; and due rest and sleep. The versatile and boundless ranging mind must wait upon the limited conditions of its subservient companion: by wisely doing which this life may last long, and the mind ceaselessly acquire increase of knowledge and power. But ever the master mind must be doing, or naught is done.

Dr. Carpenter, as a purely scientific teacher, also speaks of the soul's relation to the Infinite; and of its constituting one of the most distinctive peculiarities of man, and as the main-spring of human progress. He says the desire for improvement grows by what it feeds upon; "in the higher grades of mental development there is a continual looking upward, not towards a mere elevated human standard, but at once to something above man and material nature." He desires to participate in a spiritual existence, of which the germ has been implanted in the mind of man, and which, developed as it is by the mental cultivation, * * * has been regarded by philosophers in all ages as one of the chief natural arguments for the immortality of the soul." (Physiology, Sec. 7.) And he concludes his work on Animal Physiology, in these words: "The philosopher who has attained the highest summit of mortal wisdom, is he who, if he use his mind aright, has the clearest perception of the limits of human knowledge, and the most earnest desires for the lifting of the veil that separates him from the Unseen. He, then, has the strongest motives for that humility of spirit and purity of heart, without which, we are assured, none shall see God."

While I would thus elevate mind to its truthful distinction and preeminence, I would say nothing to disparage the material and living creation. While physicists ascribe all to matter,— all matter, all life, all mind,

—and nothing to God. I ascribe all to Him: yet regard matter as essential means to all life, and to the exhibition of all mind upon this earth. We see God's good design in physical nature, and that design we must reverence, and learn to adore Him in the sublimity of his works. Without this material earth and sun that lights and warms it, there would be none of the life that we behold—would not be human souls to people heaven. Climate, it is to be admitted, does make the Esquimau and the Negro what they are. Unfriendly to life and its happiest physical development, it is also unfriendly to intellectual, to moral, and religious culture: and it also fails either in the productions needful for man's uses and improvement, or produces animal and vegetable life so rankly as to over-master the unskilled native, until he shall be helped by the stronger and more inventive man of the temperate zone. But it follows not that the mind is the production of the surrounding physical causes, but only that these have not so well developed the instrument the minds must use: and consequently the mind itself is not so fully developed.

The mind it is that is ever conquering nature and moulding matter and ruling life. It reclaims the earth to culture, fells the forest, drains the morass, destroys wild beasts; mines the fuels and metals; makes and applies iron to its ten thousand uses; constructs railroads and telegraphs; creates the arts and sciences; educates mankind generally unto a higher civilization, and makes a large proportion almost what they should be: that is to say, learned, temperate and wise, lovers of man and worshipers of God: and all are advanced in moral conduct, except the irreclaimably vicious. The task remaining before our humanity is to endeavor to cause the people to approximate the standard of perfection: and if, peradventure, we get a majority of such, the world will have made inestimable progress. And why should we not all strive for such consummation? In every branch of business, men exert a wonderful amount of common sense and acuteness of thought, and achieve admirable success. Half the like assiduity and culture directed upon their own minds would produce a transformation of character and increase of intelligence, that would excite their wonder and the admiration of the world. Mind only can do it, but mind can work the consummation; and that is the great hope of all thoughtful, good men.

In all ages men have spoken of matter and mind: of the flesh and the spirit; of body and soul, as things of contrasted nature, and as at strife, until one has attained the rule over the other: and if that rule be of the flesh or the sensual passions, it is a dominion of sure degradation and early destruction; but if it be of the truthful mind, then is it a dominion of peace and wisdom. Paul said: "I see another law in my members warring against the law of my mind;" with the sin in those members his sense of duty was also at war: and to desist from fulfillment of the sense of duty, was to him intolerable woe. Mankind have always made such contrast, and adopted their lesson of discipline from the requisition of an exacting conscience, and by induction from surely observed facts. And when our friends are with us in life, what is it that so much engages our attachment and love and veneration for them? Not surely the body, except slightly by association, since it is the temple where higher excellence

dwell; but it is the intelligent mind, the loving heart, the well-tried virtues. And when death has taken our friend, for what is our sorrow? Not for the body, so little distinguishable from other bodies, but for the intellectual and social companion, who had requited our love, but may never again; that instructor and adviser with whom we took wise counsel, but shall no more on earth forever. It is for the social and good and generous mind that we grieve with a grief that refuses to be comforted, except as we find it in the faith that assures us we shall meet again, never again to be separated; a necessary faith of human consolation, and therefore proof to ourselves that our minds and virtuous affections shall be immortal. This was the testimony of Buckle, as to his own experiences and reflections after he had witnessed the slow decline and death of his beloved mother; testimony that refuted the skeptical philosophy of his life; and has redeemed his memory from apparent heartlessness, and made it very beautiful to those whose philosophy grasps the immortality of the soul.

Matter and life are always undergoing changes, and both, in the human body, kept in health, will live through length of happy years; but at some time they will hasten towards dissolution, and come to the end of their organism: and the life will only thereafter continue as it has been imparted to offspring. But mind or thought is everlasting, if there can only be found imperishable material to hold its expressions. If the printed page, or the canvas, or marble will endure, the thoughts of the author and artist will last forever. The eternal thought can then only be assailed through its allied perishable material; and that mind shall never perish, it only needs an imperishable, a "celestial body;" and that it should be translated into one, or live independently of one, should be no more a mystery to philosophy than that the human soul has existed in its mortal habitation; is not more questionable as within the power of the Almighty and His fulfillment of the logic of His creation, than the fact that a blade of grass shall grow, or that this body is now the habitation of a human life.

The subject of this discourse might be continued through volumes, and the writer be all the while dealing with as veritable realities as those that occupy the physicist or naturalist, whose great deficiency so often is, that he becomes so wedded to the material that he disregards the mental and moral in his philosophizing, and is, therefore, possessed of but half the facts needful as a basis whence to make induction of all the great truths of Creation. He needs to know more to become wiser and more charitable; and the metaphysician and theologian also need to know all the truths of physical nature the former can develop, all of them God's truths, that they may become more fully informed, and, perhaps, more charitable: that they may clearly know the physical works and laws of the Creator, and the more perfectly love and adore Him. Each class is in possession of numberless invaluable truths, but neither possesses so many as it should know; and this is partly owing to the wall of partition their hostility has erected between them. While it is natural that each should cling strongly to its convictions, these convictions must be based upon all facts requisite to truth, that they may endure.

And here let me not be understood as making a general charge

materialism against physicists, for I am happy in believing that the great majority of physicists are not materialists. I give credit to all who disavow a materialistic faith, including Dr. Huxley ; giving credit to the like disavowals here, there is no materialist known to me in this Society. I have been enabled to use the authority and facts furnished by eminent physicists, with great advantage, to sustain the views expressed in this essay, as those of Bichat, Morgan, Carpenter, Holmes, and Tyndall.

While the drift of Professor Huxley's lay sermon favors materialism, there is that in "systematic materialism" that repels him as something pernicious. The last words of the sermon are these : "The errors of systematic materialism may paralyze the energies and destroy the beauty of life." He has some other faith, therefore, which preserves him from the deadly influence he deprecates, and the loss of the sense of the beauty of life which he loves. It can only be a more elevating philosophy, by his concession, that can preserve to us a sense of the beauty of life ; may we not say, "the beauty of holiness?" Such good fruit must be proof of the greater truth of the higher philosophy he conceives and believes, yet does not explain or advocate, but has sought to supplant. Now how only do men attain their highest sense and example of this "beauty of life?" It is by a belief in the immortal life, and by cherishing the highest ideal of perfection, which that belief ever presents to our apprehension, with an obedience to the injunction to strive to be perfect as the higher perfection ; even looking to the perfection "of our Father in heaven." That cannot be the truth of life that could "paralyze the energies and destroy the beauty of life." Why then seek to build up a philosophy which condemns itself? Why seek to establish a theory at which our given sense of truth and beauty revolts? Why seek to entomb the mind in matter, and thereby lose our own soul? The useful, the beautiful, and the perfect in God's creation attest the truths thereof and that it is His. It remains ever to be a sure test, by their fruits are all things to be known.

I would now leave it, as the testimony of one who has lived longer than the allotted three score years and ten, not unobservant of men, nor unreflecting upon the question of the wherefore of our being, with a mind consciously open to the reception of every truth presented, for all that the conviction of one mind may be worth,—that the doctrine of materialism cannot be adopted as a belief of mankind, until men shall become capable of confounding things the most opposite in nature ; until they can believe that light can be darkness ; good be evil ; right, wrong ; not until men can dissever effect from its due cause ; logic from reason ; creation from its Creator. Not until then, will they confound mind with matter. All nature demands a broader and truer interpretation, wherein every part shall have assigned to it its just significance, and unto the whole its adequate import be ascribed. Each and all imply no less than that there is a Creator, and that the human soul has a life immortal. If the soul of man has not this significance, then, truly, Creation is without adequate motive or result for all eternity. But if we be children and heirs of God, there is a sufficient solution of the purpose of our being, and an object worthy the glory of the universe.

CORRELATIONS OF COSMICAL AND MOLECULAR FORCE.

By Pliny Earle Chase,

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(*Read before the American Philosophical Society, February 16th, 1872.*)

If it be granted

1. That all forms of terrestrial organic energy are transformed modifications of solar radiation;
2. That centrifugal and centripetal energies tend continually to equilibrium:
3. That the kinetic energy of a perfectly elastic medium under constant pressure, bears a definable ratio to its kinetic energy under constant volume:

Then the *kinetic energy of dissociated water should be, approximately, to the kinetic energy of terrestrial revolution, as the mass of the earth, is to the mass of the sun.*

And *the energy of hydrocarbons should be, approximately, to the energy of dissociated water, as elastic energy under constant volume, is to elastic energy under constant pressure.*

For the measures, of the energy of gaseous combustion, and of the energy of orbital revolution, are, respectively, the mean height of oscillation excited by the igneous energy of the combustible compound, and the mean distance from the sun at which the earth is sustained in its orbital revolution. It is evident, from the well known laws of elasticity, that if a perfectly elastic body were lifted, *in vacuo*, to any given height, and then let fall, it would rebound to the height from which it fell, and this oscillation would be perpetual, unless disturbed by extraneous forces, in the same way, and for a similar reason, that the earth continues its elliptical oscillation about the sun. Inasmuch as the total radiating force is considered in each instance, [the time consumed in storing up and in liberating the accumulated solar energy being left entirely out of question,] the element of velocity is not involved in the preliminary determination. It may, however, be subsequently ascertained, if desired, by the formula, $v = \sqrt{2gh}$.

It is evident that the dissociated oxygen and hydrogen tend to expand, in consequence of any liberated interior energy, under constant exterior pressure, while the hydrocarbons are restrained by the cohesive forces which tend to maintain a constant volume.

For the purpose of testing the accordance, both of the postulates and of the conclusions, with the facts of observation and experiment, it might be deemed sufficient to confine attention exclusively to the lightest and most elastic gas, and to the lightest and most volatile liquid. But I believe the same principles, with simple modifications, are applicable to all forms of matter, and I have already extended the investigation, with some encouraging results, to inorganic elements and compounds. I subjoin, from Muspratt's Chemistry, all the elements and products involved

in the unstable equilibria of organic life, for which I have been able to find any recorded experimental value. In all cases which have been tested by more than one observer, the kinetic ratios represent the mean of all the latest and most authentic results. For convenience of expression, I employ the following symbols:

d—length of terrestrial day.

y'—duration of orbital revolution of the earth.

y''— " " " " the moon.

y'''— " " " " a hypothetical satellite at the surface of the earth.

g—32.0874377 feet.

r—radius of the earth=20,923,654 feet.

$c', c'' \ldots . c_{xvi}$ = combustible (hydrogen, ether, ... carbon).

$\gamma_x (\gamma' \gamma'' \ldots . \gamma_{xvi})$—product of combustion.

t_x $(t', t'' \ldots . t_{xvi})$—thermal units, or number of pounds of water heated 1° C. by the combustion of 1 pound of c_x

J—Joule's equivalent, $\frac{193}{1320}$ mile—pounds.

w_x—weight of γ_x : weight of c_x.

η_i'—mean height at which the earth is suspended under the centrifugal force of the sun.

η_i''— " " " moon " " centrifugal force of the earth.

h_x—mean height at which γ_x would be suspended, in the oscillation maintained by combustion and gravitation=$J \times t_x : 2 w_x$.

$\eta_i' \div h_x = \mu_x$, approximation to solar mass in units of earth's mass, furnished by c_x.

k_x—kinetic ratio of $c_x = \mu_x \div \mu'$

ρ_x—ratio of experimental to theoretical value of k_x.

m', m'', m'''—mass of sun, earth, moon.

	c_x	Symbol.	γx	k_x	ρx	Authorities *
1	Hydrogen	H	HO	1.000	1.000	D, H, G, F&S, A
2	Ether	C_4H_5O	$4CO_2, 5HO$	1.494	1.004	D., F&S.
3	Olive Oil	$C_{10}H_8O$	$10CO_2, 8HO$	1.495	1.004	D.
4	Terebene	$C_{10}H_8$	$10CO_2, 8HO$	1.503	1.010	F&S.
5	Marsh Gas	CH_2	$CO_2, 2HO$	1.518	1.020	D., G., A., F&S.
6	Amylic Ether	$C_{10}H_{11}O$	$10CO_2, 11HO$	1.521	1.022	F&S.
7	Phosphorus	P	PO_5	1.529	1.027	A.
8	Olefiant Gas	CH	CO_2, HO	1.534	1.030	D., G., F&S., A.
9	Oil of Turpentine	C_5H_4	$5CO_2, 4HO$	1.542	1.036	G., F&S.
10	Oil of Lemons	$C_{10}H_8$	$10CO_2, 8HO$	1.545	1.038	F&S.
11	Fusel Oil	$C_{10}H_{12}O_2$	$10CO_2, 12HO$	1.596	1.072	F&S.

* A., Andrews. D., Dulong. F&S., Favre and Silbermann. G., Grassi. H., Hess. I reject Dalton's determinations of k_x for camphor (2.808), because in nearly every instance he obtained much higher values than any later experimenters. Further experiments with that substance ($C_{10}H_8O$, yielding $10CO_2, 8HO$) would be interesting, and perhaps suggestive.

12 Alcohol	$C_4H_6O_2$	$4CO_2, 6HO$	1.601	1.076	D., G., F&S., A.
13 Cyanogen	C_2N	$2CO_2, N$	1.647	1.106	D.
14 Acetone	C_3H_3O	$3CO_2, 3HO$	1.681	1.129	F&S.
15 Wood Spirit	$C_2H_4O_2$	$2CO_2, 4HO$	1.722	1.157	G., F&S.
16 Carbon	C	CO_2	1.853	1.245	D., G., H.

The following examples indicate the manner in which the several values are determined:

$$h' = J \times t' \div 2w' = \frac{193}{1320} \times \frac{34533}{2 \times 9} = 280.5 \text{ miles.*}$$

$$h_{xi} = J \times t_{xi} \div 2w_{xi} = \frac{193}{1320} \times \frac{8959 \times 11}{2 \times 41} = 175.7 \text{ ``}$$

$$k_{xi} = h_{xi} : h_1 = 1.596$$

If an elastic fluid is lifted above the earth's surface, subject to the (nearly) constant pressure of gravity, the superficial pressure varies as $\left(\frac{r+h}{r}\right)^2$, and the volume as $\left(\frac{r+h}{r}\right)^3$. The value of h for HO being, as we have seen, 561 miles (or twice h_1, which represents the *mean* height of oscillation), if we call r (earth's mean radius) 3956 miles, $\left(\frac{r+h}{r}\right)^3 = 1.4886$. This corresponds approximately to the experimental valuation adopted by Tyndall (1.421), and is almost identical with the experimental kinetic ratio of ether (1.494).

$y''' = 2\pi\sqrt{r \div g} = 5074$ seconds.

$y'' = 27$ dys, 7 h., 43 min. 12 s.

$r_{,}'' = (y'' \div y')^{\frac{2}{3}} \times r = 237937$ miles.

By my hypothesis,

$$h' : r_{,}' :: m'' : m' \quad \therefore m' = m'' \frac{r_{,}'}{h'}$$

And, according to well known mechanical laws.

$$m' = m'' \left(\frac{r_{,}}{r}\right)^3 : \left(\frac{y'''}{y'}\right)^2$$

Solving the equations, we obtain the following values:

Sun's mass 330,260

" distance 92,639,500 miles.

* If e represents the extreme excursion of the exploded gases, the centre of gyration, considering the earth's surface as the axis, being $\frac{2e}{3}$, the secondary centre of oscillation, on the return towards the centre $\frac{e}{2}$, is at $\frac{5e}{9}$, and $\frac{5}{9}$ of 34533° C. = 34533° F.

THE HERSCHELL-STEPHENSON POSTULATE.

By Pliny Earle Chase.

(*Read before the American Philosophical Society, March 1st,* 1872.)

Of the three postulates which I submitted to the Society at its last meeting, I presume the first will generally be considered the most questionable. The hypothesis of Herschel and Stephenson, that the coal consumed under our boilers merely imparts, to the steam, solar energies which have been imprisoned for ages by the molecular attraction of the carbon particles, has been commonly accepted as a beautiful poetical fancy, having, perhaps, some indefinite foundation in truth. Few persons, however, can have indulged the expectation that so vague a surmise would ever yield any satisfactory numerical results, and it will not be strange if even the close coincidences to which it has led me, may be regarded by many as merely accidental.

The following comparisons show the character of the agreement between estimates of solar distance, mass, and parallax, based upon various chemical and astronomical observations:

I. By Flame Analysis.

According to Experiments of	Distance.	Mass.	Parallax. ″
Andrews	93,631,000	340,950	8.73
Favre and Silbermann	92,471,000	338,430	8.839
Grassi	92,466,000	328,370	8.84
Dulong	92,363,000	327,290	8.85
Hess	92,298,000	326,590	8.856

II. By Astronomical Computation.

According to Calculations of	Distance.	Mass.	Parallax. ″
Encke	95,311,000	359,630	8.576
Liais	93,309,000	337,440	8.76
Newcomb	92,380,000	327,480	8.848
"	92,152,000	325,040	8.87
Stone, corrected	91,945,000	322,900	8.89
Hansen	91,672,000	319,990	8.9165
Stone	91,512,000	318,320	8.932
Leverrier	91,329,000	316,470	8.95
Wineke	91,186,000	314,930	8.964

My own faith in the significance of such coincidences, and in their suggestive value as indications of an instructive, intelligent as well as intelligible, purpose in nature, inclines me to the acceptance of speculations, based on thermodynamic, spectroscopic, and analogous theories, even before all their premises have been recognized as either axiomatic or rigidly demonstrable. The desirableness, however, of completing the

proof as soon as possible, must be admitted, and I now submit some further considerations, which, in my own judgment, impart a more strictly mathematical character to my fundamental postulate.

It is well known that the velocity acquired in falling towards an attractive centre, depends upon the attracting mass and the distance fallen through. In other words,

$$v \propto \sqrt{2gh} \propto \sqrt{\frac{2mh}{d^2}} \propto \frac{2h}{d}\sqrt{\frac{m}{2h}}$$

It is moreover evident that in any perfectly elastic particle, oscillating perpetually in a compound orbit, about two centres of attraction, as in the hypothetical case of water vapor, set in motion by the force of chemical combination, if

$$m \propto 2h,$$

the proportionate velocity communicated by gravity varying as $\sqrt{\frac{2h}{d}}$, the proportionate living force will vary as $\frac{2h}{d}$. The mean amounts of living force imparted by each of the two attracting centres will then tend constantly to equality, thus counteracting any indefinite expansion or contraction towards the centre of prepondering attraction, which would otherwise gradually draw the oscillating body to itself. This exigency can be satisfied, and a perpetual oscillation maintained by the conjoint action of gravity and elasticity, only when $2h$ has the proportional value here indicated.

The question may be approached in another way. The sustaining *vis viva* of the earth in its orbit, having been acquired by a virtual fall through the half-radius $(h' = \frac{d'}{2})$, let it be required to find the proportionate part of the possible fall which will sustain the elastic oscillation.

Since the attracting forces (or the virtual masses acting at the point of disturbance), vary as $\frac{m}{d^2}$, the virtual centrifugal forces will vary as $\frac{m}{d}$. Then

$$2h'' : d'' :: \frac{m''}{d''} : \frac{m'}{d'} :: m'' d' : m' d''$$

$$\therefore\ 2h'' \propto \frac{m'' d'}{m'};\ \frac{m''}{2h''} \propto \frac{m'}{d'};\ m \propto 2h \propto d.$$

At whatever distance from the centre the elastic particle encounters an obstacle, a portion of the force must be communicated to the obstacle, originating new molecular motions, which, if they could all be known, would show that the aggregate amount of force is still maintained. The following attempt to trace a portion of the transmitted forces of inter-

rupted oscillations, may perhaps suggest others that will be more complete and satisfactory :

Let $\frac{m'}{m''} = \frac{\text{sun's mass}}{\text{earth's mass}} = 314{,}000$*

$d' = 91{,}328{,}000$

$d'' = 3{,}962.8$

$h'' = \frac{m''d'}{m'} = 290.85$

v' = hourly velocity of a body revolving at the distance d' from the sun's centre, or at the distance h'' from the earth's centre, = 65,062.4 miles.

In consequence of the solidity of the earth, the hypothetical perpetual oscillation of the combined H and O through the major axis $2h''$, must be maintained at d'' instead of at h'' from the earth's centre. Its maximum velocity is therefore only $\frac{2h''}{d''}$ of v', which $= 9609.36$ miles $= 9.24\times$ the equatorial superficial velocity of rotation, or $9.0165\times$ the velocity at the centre of oscillation of the semi-axis h.

The reaction of the elastic atmospheric particles, in their continual rebounds from the earth's surface, under tidal, thermal, chemical, and molecular influences, should contribute, in connection with the motion of revolution, to a rotary motion in the earth itself. The following coincidences, at the boundary lines of the interior (Telluric) and exterior (Jovian) planetary systems, seem to render it probable that a reference to centres of oscillation may ultimately account for the masses, order of arrangement, and times of rotation, of the several planets and satellites, as well as for their period of revolution.

If we assume, in the sun, as well as in the oscillating H_2O, a virtual centre of oscillation at the distance $\frac{r}{9}$ from the diametrical centre, the oscillating centre will move about a sphere, which has a volume, proportioned to that of the solar sphere, as 1 to 9^3.

If all the asteroids, satellites, comets, meteors, and undiscovered planets in our system constitute an aggregate equivalent to the mass of Uranus, the mass of the sun is 729 ($=9^3$) $\times$ the planetary mass. (*a.*)

$729\times\frac{1}{9}$ ($=9^2$) solar radii = distance of Mercury. (*b.*)

729×1 ($=9^3$) " " = distance of farthest asteroid. (*c.*)

729×9 ($=9^4$) " " = distance of Neptune. (*d.*)

	Theoretical.	Observed.	Theoretical Error.
a	.0013717	.0013584	+.009
b	34,430,000	35,353,000	—.027
c	309,870,000	312,388,000	—.008
d	2,788,833,000	2,743,216,000	-.017

* The values are taken from Norton's Astronomy.

FURTHER APPROXIMATIONS TO THE SUN'S DISTANCE.

By Pliny Earle Chase.

(*Read before the American Philosophical Society, April 5th,* 1872.)

If it be true, as is commonly and very plausibly supposed, that molecular and cosmical laws have many significant analogies which are yet undiscovered, it may be well to seek for such analogies wherever we may reasonably hope to find them.

The height of oscillation which I have assumed as the measure of the igneous energy of combustibles, is less, and the resulting estimate of solar mass and distance is greater, if the combustible is dense, composite, or of small specific heat, than if it is rare, simple, or of great specific heat. It seems likely that even hydrogen, the most volatile of all known substances, may have undergone some condensation and loss of specific heat, and that, therefore, my first estimates by flame analysis* were all slightly in excess. This opinion is the more probable, from the fact that the mean of the most recent astronomical estimates of solar distance, is nearly one per cent. less than the mean of the flame estimates.

In searching for some clue to the coëfficient of condensation in hydrogen, if we accept the hypothesis that the luminiferous æther is a perfectly elastic material medium, we may, perhaps, be able to detect some important relations between the velocity of luminous or thermal undulations, and the velocity of oscillations which are directly traceable to gravitating action. In the primary radiation and subsequent double concentration of exploding hydrogen, there is not only a joint attraction of the gaseous particles for each other and of the whole for the earth, but there is also a generation of luminous vibrations, with a velocity such as would be produced by a gravitating force $g = \frac{v^2}{h}$. Equivalent velocities may be generated by masses of different magnitudes, provided the motion is orbital with radii varying as the masses, or the fall is virtually continued to the centre from heights equivalent to twice those proportionate radii. With these preliminary considerations I invite attention to the following coincidences:

1. At the centre of oscillation of the extreme excursion of exploding H_2O before its fall towards the centre of condensation, ($\frac{2}{3}$ of 1009.877 miles from the commencement of the fall, or $\frac{1}{3} \times 1009.877 = 336.626$ miles above the earth's surface,) the velocity imparted by terrestrial gravity in one year $\left(\frac{32.0894377 \times 31558150}{5280} \div \left(\frac{3962.818 + 336.626}{3962.818}\right)^{\frac{1}{2}} = 184,130 \text{ miles}\right)$ would be closely coincident with the velocity of light. If the coincidence is exact, $r_\prime$ (the Sun's distance) is $497.827 \times 184,130 = 91,665,370$ miles. The value of h corresponding to this distance $\frac{2gt^2r^2}{4\pi^2 r_\prime^2} = 573.099$ miles, which is 1.0215 times the experimental h (561.043 m).

* Ante, p. 385.

2. In consequence of the equality of velocities at γ and $h_{\odot}$, t (the time of revolution) $\propto h$. If the mass $(\oplus \div ☽) = 81$, $\left(\frac{82}{81}\right)^{\frac{3}{2}} \times 561.043 = 571.436$. In other words, *the actual* : *the experimental* value of h : : the virtual time of revolution of the Earth's centre, relatively to the Moon : the virtual time of revolution of the centre of gravity of the Earth and Moon. If this proportionality is exact, the value of γ is $\frac{tr}{\pi}\sqrt{\frac{g}{2h}} = 91,798,500$ miles.

3. The greatest distance of the Moon from the Earth is about $63r$, and $\frac{h}{h+r}$ is nearly equivalent to $\sqrt{\frac{1}{63}}$. If this equation is exact $h = 571.25$; $\gamma = 91,813,400$.

4. The velocity acquired by falling through h, from the distance $r+h$, is nearly a mean proportional between the velocities of terrestrial rotation and revolution. If $h = 569.363$, $\gamma = 91,965,500$ and the hourly velocity of revolution is $2 \times 3.14135 \times 91,965,500 \div 8766.153 = 65,911.7$; $3600 \times \sqrt{2gh \div \frac{h+r}{r}} = 8,280.6$, which is a mean proportional between 65,911.7 and 1,040.3. I can find no indication, in any of the planets or satellites, of a greater rotation-velocity than is thus indicated, and as it is difficult to conceive the possibility of such a velocity, I am inclined to regard this as the upper limit of possible value for γ, and to believe, therefore, that the Sun's mean distance cannot be greater than 91,965,500 miles.

5. If we take h' a third proportional to r and h $\left(h' = \frac{h^2}{r}\right)$, the *vis viva* of rotation of an elastic particle at the Earth's surface : the *vis viva* at h' : : the force of gravity at h' : the force of gravity at the Earth's surface : : the velocity of light : the velocity which would be communicated by superficial gravity in one sidereal year.

$$497.827gt : \left(\frac{r+h'}{r}\right)^2 = \gamma = \frac{tr}{\pi}\sqrt{\frac{g}{2h}};$$

$$\therefore 497.827\pi \times r\sqrt{2g} = \frac{(r+h')^2}{\sqrt{h}}.$$

$$\text{If } h = 573.967,\ \frac{r}{h} = 6.90425;\ h' = 83.1323;\ \frac{(r+h')^2}{\sqrt{h}} = 683,279.4;$$

$$\gamma = 91,595,960.$$

We thus obtain five independent determinations, each of which is based upon considerations, some of which are necessary resultants of known mechanical laws, while others are expressive of actual circumstances of equilibrium, the greatest difference between any two of the results being less than one-half of one per cent. The experimental determination from the combustion of hydrogen (1), which differs less than one-hundredth of

one per cent. from Hansen's estimate, and only one twenty-fifth of one per cent. from the mean of all the estimates, may, perhaps, be reasonably regarded as entitled to the greatest weight. The narrow compass within which they are all embraced, and the close approximation to the mean of the best astronomical computations, may be seen in the following table:

Newcomb (mean of two estimates)	92,266,000
TERRESTRIAL ROTATION (upper limit)	91,965,500
LUNAR DISTANCE	91,813,400
LUNAR MONTH	91,798,500
MEAN OF MECHANICAL ESTIMATES	91,767,736
Stone (mean of two estimates)	91,728,500
Hansen	91,672,000
HYDROGEN EXPLOSION (1)	91,665,320
Mean of Astronomical Estimates	91,636,300
VELOCITY OF LIGHT	91,595,960
Leverrier	91,329,000
Winnecke	91,186,000

Is it possible that there can be anything deceptive in these figures,—that any bias of unsuspected prejudice may have blinded me, or that I have been misled by mere fortuitous resemblances? The question whether there is not some conception of force which will unify centrifugal and centripetal, luminous, thermal, and gravitating action, is continually recurring; the accordance of Faraday's "lines of force" with lines of perfect fluidity, and the fundamental equation of oscillation, favor an affirmative answer; the increasing popularity of the theory that matter is nothing but force, prepares the way for every conceivable approximation and identification of molar and molecular laws.

If the undulations of light have any influence upon the gravity of bodies, the velocity of light being nearly uniform, its influence should tend to communicate a velocity as nearly like its own as gravity and inertia will allow, a tendency which is presumably most manifest in the most tenuous forms of matter. The gravitating velocity,

$\sqrt{\frac{r}{r+h}\,2gh} \propto \sqrt{\frac{1}{r+h}\,2mh}$, being a maximum when $r = h$ and $h \propto m$, it does not seem unreasonable to look for analogies between the extreme excursions of planets, satellites and gases, or between times, velocities, and living forces, in the direction of that maximum.

GENERAL RELATION OF AURORAS TO RAINFALL.

By Pliny Earle Chase.

(Read before the American Philosophical Society, April 5th, 1872.)

In order to ascertain if the parallelism, which I have pointed out between the daily rainfall and the frequency of auroras, can be traced in the annual curves, I have constructed the following table of normals, from data furnished by Lovering's Catalogue of Auroras, and Loomis's Meteor-

logy. The tendency to increase of auroras in clearing weather, and iminution in falling weather, is shown in the Auroral and Pluvial eneral Means:

	Auroras.				Rainfall.			
	New England.	Western Hemisphere.	Eastern Hemisphere.	General Mean.	Lat. 5° 44′ to 35° 41′	Lat. 36° 9′ to 42° 20′	Lat. 42° 21′ to 57° 31′	General Mean.
Jan.	89	96	107	97	78	97	116	97
Feb.	100	107	125	111	75	95	103	91
March,	112	112	136	120	75	100	93	89
April,	107	103	116	109	83	106	89	93
May,	90	86	73	83	105	107	87	100
June,	84	77	42	68	129	106	84	106
July,	92	85	45	74	141	103	84	109
Aug.	109	103	79	97	138	97	89	108
Sept.	120	118	119	119	119	92	101	104
Oct.	118	117	133	123	96	94	113	101
Nov.	96	103	120	106	82	102	120	101
Dec.	81	93	105	93	80	103	122	102

INFLUENCE OF METEORIC SHOWERS ON AURORAS.

By Prof. Pliny Earle Chase.

(Read before the American Philosophical Society, May 16th, 1872.)

Professor Lovering's discussion of the periodicity of the Aurora Borealis Trans. A. A. S. Vol. X., Part I.), not only exhibits maxima and minima f frequency at periods corresponding to general minima and maxima of ainfall (see above), but it also furnishes evidence of a tendency, in other reat atmospheric disturbances, to increase auroral displays.

In preparing the following table, I first took the second means of ,overing's Table LII. (containing 10316 auroras, arranged according to heir frequency on each day of the year). After grouping the results in ive-day periods, I calculated the ratio of each ordinate to a mean ordinate f 100. Against each ordinate which corresponds to a supposed meteoric eriod, I set the initial K. (Kirkwood's "Meteoric Astronomy"), or W. Wolf, cited by Lovering, p. 221).

COMPARATIVE TABLE OF AURORAL AND METEORIC DISPLAYS.

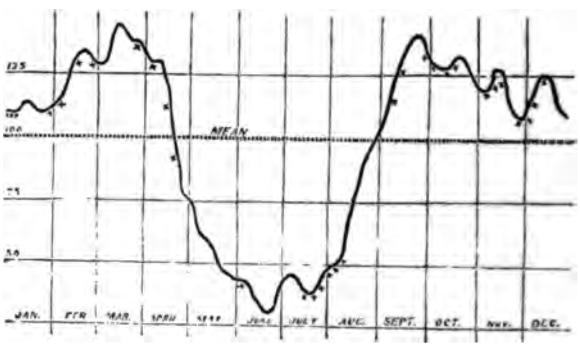
Jan. 3, 110 K., W.	Mar. 19, 144	June 2, 44	Aug. 16, 76	Oct. 30, 126
8, 110 W.	24, 138	7, 44 W.	21, 88	Nov. 4, 120
13, 114	29, 138 W.	12, 41	26, 95	9, 121 W.
18, 113	Apl. 3, 133	17, 35	31, 102	14, 129 K., W.
23, 110	8, 130 W.	22, 31	Sep. 5, 112	19, 127 W.
28, 111	13, 131	27, 36	10, 123 W.	24, 113
Feb. 2, 113 W.	18, 118 K., W.	July 2, 40	15, 131 W.	29, 109 K., W.
7, 116 W.	23, 94 K.	7, 46	20, 138	Dec. 4, 115 W.
12, 125	28, 79	12, 44	25, 142	9, 122 K., W.
17, 133 K., W.	May 3, 76	17, 40 W.	30, 139 W.	14, 127 K., W.
22, 134	8, 66	22, 39 K.	Oct. 5, 133 W.	19, 125
27, 132 W.	13, 61	27, 45 K., W.	10, 129	24, 114
Mar. 4, 129	18, 57	Aug. 1, 49 K., W.	15, 129 K.	29, 111
9, 133	23, 51	6, 51 K., W.	20, 133 K.	
14, 145	28, 47	11, 60 K., W	25, 132	

The table, as well as the accompanying curve, exhibits the following peculiarities:

1. The principal maxima occur near the equinoxes, and are apparently due to the favorable position of the earth for the development of circulating electric currents.

2. There is an evident grouping of meteoric displays in the vicinity of the maxima and minima.

3. The grouping is more strongly marked upon the ascending, than on the descending sides of the inflections.



4. The principal secondary maxima (in February, October, November and December), exhibit the most striking accordance.

5. Nearly all of the apparent exceptions to this general accordance are occasioned by the rapid decline of the general curve, which is so great as to veil the subordinate maxima, when five-day means are taken.

Of all the meteoric ordinates suggested by Kirkwood, including those which he regards as doubtful, three correspond with auroral minima; eight with increasing auroral displays, two with maxima, and only two with ordinates of diminishing auroral frequency. The two exceptions

ordinates become normal if we examine the daily curve of second means, which shows subordinate maxima on April 19th and April 24th.

Of the meteoric ordinates suggested by Wolf, four correspond with minima, nine with ascents, seven with maxima, and six with descents in the auroral curve. Of the six apparently abnormal ordinates, only two, those of March 31st and Nov. 19th, are on descending inflections of the auroral daily curve of second means.

There seems, therefore, good reason to look for an increase of auroral displays, soon after every meteoric shower.

PLANETARY ILLUSTRATIONS OF EXPLOSIVE OSCILLATION.

By Pliny Earle Chase.

(*Read before the American Philosophical Society, May 16th*, 1872.)

The secondary centre of gyration in an exploded gas, on its return towards the centre of gaseous mass, being, as I have shown, at $\frac{5h}{9}$ (h representing the extreme excursion consequent on the explosion), we may reasonably expect, by referring the planetary masses to similar primary and secondary centres, to obtain evidence relative to the probability of the hypothesis of molar and molecular correlations. Whether the nebular hypothesis be true or false, the planets are oscillating under the combined action of centrifugal and centripetal forces. In their continual virtual fall towards the Sun, they are subject to such disturbances as arise from their mutual interaction, and should, therefore, tend to arrange themselves somewhat like the particles of an exploded gas. I submit the following exemplifications of such a tendency, the calculations being generally based upon the hypothesis that the planets are either in conjunction, or nebulously diffused along the entire line of their orbits.

1. Mercury is near the theoretical mean excursion $\left(\frac{5h}{9}\right)$ of the centre of gravity of the intra-asteroidal belt of planets.

Mercury*	$3\frac{1}{3}\times$	.3871	= 1.2903
Venus	$25\times$	.7233	18.0832
Earth	$31.85\times$	1.	= 31.85
Mars	$3\frac{1}{3}\times$	1.5237	5.079
	$63.52\times$	.8864	56.3025

$\frac{5}{9}\times .8864 = .4924$ from the centre of gravity, or .3940 from the Sun, the true distance being .3871 ; $\frac{3940}{3871} = 1.0178$.

2. The actual eccentricity of Mercury's orbit : the theoretical eccentricity if the oscillation were referred primarily to the intra-asteroidal

* The values of the astronomical elements are taken from Norton's Astronomy, unless otherwise stated.

centre of gravity, nearly : : the actual : the theoretical mean excursion from that centre of gravity.

Theoretical eccentricity, $2 \times (\frac{5}{9} - \frac{4}{9}) = \frac{2}{9}$; $.205515 \div \frac{2}{9} = .92482$.

$(.8864 - .3871) : \frac{5}{9} = .89874$; $\frac{.92482}{.89874} = 1.029$.

3. Neptune is near the theoretical explosive centre of the centre of gravity of the three exterior planets.

$$[2847.4 \times 9.539 + 416.7 \times 19.182639 + 532.5 \times 30.037] \div$$
$$[2847.4 + 416.7 + 532.5] = 13.472;\ 13.472 \div (1 - \tfrac{5}{9}) = 30.312;$$
$$30.312 \div 30.037 = 1.009$$

4. Neptune's orbital centre of oscillation is near the orbit of Uranus.

$$\tfrac{2}{3} \text{ of } 30.03697 = 20.02465;\ \frac{20.02465}{19.182639} = 1.0439.$$

5. The orbital centre of oscillation for Uranus, is near the centre of gravity of the three exterior planets. The mean orbital radius of Uranus is about twice that of Saturn.

$$13.472 \text{ (See No. 3)} \div (\tfrac{2}{3} \times 19.182639) = 1.05345.$$

6. The theoretical mean excursion for an explosion from the Sun to Uranus, is near the centre of gravity of Uranus and Saturn.

$$\tfrac{5}{9} \text{ of } 19.18264 = 10.657;\ (2847.4 \times 9.539 + 416.7 \times 19.18264) : (2847.4 + 416.7) =$$
$$10.7697;\ 10.7697 \div 10.657 = 1.0106.$$

7. The theoretical mean excursion for an explosion from the Sun to Saturn, is near the orbit of Jupiter.

$$\tfrac{5}{9} \text{ of } 9.539 = 5.299;\ 5.299 \div 5.203 = 1.018.$$

8. The centre of gravity of Jupiter and Saturn is near Saturn's orbital centre of gyration.

$$(\tfrac{2}{3} \times 9.538852) : \left(\frac{2847.4}{12154.4} \times 4.33605 + 5.2028\right) = 1.0226.$$

9. The theoretical mean excursion from Jupiter to the Sun, is near the inner limit of the asteroidal belt.

$$(1 - \tfrac{5}{9}) \times 5.2028 = 2.31236;\ 2.31236 : 2.2014 = 1.05.$$

10. The centre of gyration of Jupiter's orbital radius is near the exterior limit of the asteroidal belt.

$$\tfrac{2}{3} \text{ of } 5.2028 = 3.4686;\ 3.4686 : 3.4205 = 1.01406.$$

11. If all the known primary planets were aggregated at Jupiter's orbital centre of gyration, the centre of gravity of the solar system would be near the Sun's surface.

$$3.4686 \times 214.86 = 745.248;\ 759.46 : 745.284 = 1.01908.$$

12. The centre of oscillation for the exterior asteroid, is near the orbit of the inner asteroid.

$$\tfrac{2}{3} \text{ of } 3.4205 = 2.2803;\ 2.2803 : 2.2014 = 1.03584.$$

13. The centre of oscillation for the theoretical inner asteroid, is near the orbit of Mars.

$$\tfrac{2}{3} \text{ of } 2.2803 = 1.5202;\ 1.523691 : 1.5202 = 1.0023.$$

14. The centre of oscillation from Mars to the Sun is near the orbit of the Earth.

$$\tfrac{2}{3} \text{ of } 1.5237 = 1.0158.$$

15. The theoretical mean excursion from Mars to the Sun, is near the orbital centre of oscillation for the Earth.

$$(1-\tfrac{5}{9})\times 1.5237 = .6772\,;\ .6772 \div .6667 = 1.01575.$$

16. The theoretical mean excursion from the Sun to the Earth is nearly midway between the orbits of Mercury and Venus.

$$(.3871 + .7233) : 2 = .5552\,;\ \tfrac{5}{9} \div .5552 = 1.0006.$$

17. The theoretical mean excursion from Mars to the Sun, is near the centre of gravity of Venus and Mercury.

$$(3\tfrac{1}{3}\times .3871 + 25\times .7233) \div (3\tfrac{1}{3} + 25) = .6838\,;\ .6838 \div .6772 \text{ (See No. 15)} = 1.01.$$

18. The theoretical mean excursion from the Earth to the Sun, is near the extreme excursion or aphelion of Mercury.

$$.4666 \div (1-\tfrac{5}{9}) = 1.05.$$

19. The theoretical mean excursion from Venus to the Sun is nea Mercury's perihelion.

$$(1-\tfrac{5}{9})\times .72333 = .32148\,;\ .32148 \div .3075 = 1.04542.$$

20. The theoretical mean excursion from Mercury to the Sun is near the limit of the Sun's possible atmosphere (the limit at which the equatorial centrifugal force is equal to gravity).

$$[(1-\tfrac{5}{9})\times .3871]^{\frac{3}{2}}\times 365.2564 = 26.065\,;\text{*}\ 26.065 : 25.187 = 1.035.$$

21. If the several planets were aggregated precisely, as they are approximately, at direct or reverse centres of oscillation, the centre of inertia of the entire planetary system ($\sqrt{\Sigma mr^2 : \Sigma m}$) would be near the orbit of Saturn.

$$(3\tfrac{1}{3}\times 1^2 + 25\times 2^2 + 31.85\times 3^2 + 3\tfrac{1}{3}\times 4^2 + 9307\times 18^2 + 2847.4\times 27^2 + 416.7\times 54^2 + 532.5\times 81^2) : (3\tfrac{1}{3} + 25 + 31.85 + 3\tfrac{1}{3} + 9307 + 2847.4 + 416.7 + 532.5) = 27.28^2\,;\ 27.28 : 27 = 1.0104.$$

22. Notwithstanding the variations from centres of oscillation, consequent upon mutual planetary interactions, the centre of planetary inertia is still near the orbit of Saturn.

$$\Sigma mr^2(1{,}150{,}671{,}134) \div \Sigma m(13167.12) = 9.348^2\,;\ 9.5389 \div 9.348 = 1.0204.$$

23. The distance of the Moon's orbital centre of oscillation from the centre of the Earth, is very nearly a mean proportional between the limit of the Earth's possible atmosphere and the Moon's orbital radius.

$$(\tfrac{1}{3})^2 \text{ of } 238{,}800 = 26{,}533\,;\ (24 : 1.40937)^{\frac{2}{3}}\times 3962.818 = 26{,}230\,;$$
$$26{,}533 : 26{,}230 = 1.01155.$$

24. The *vis viva* of revolution at the Earth's surface : the equatorial *vis viva* of rotation, nearly : : Earth's orbital radius : twice Moon's radius of orbital gyration.

$$(17{,}066 \div 1040.3)^2 : \left(91{,}328{,}000 \div \frac{4\times 238{,}800}{3}\right) = 1.00545$$

* The approximate coincidence of this period with Hornstein's magnetic cycle ($26\tfrac{1}{3}$ days. *Vienna Academy*, June 15, 1871) is noteworthy.

SOLAR AND PLANETARY ROTATION.

By Pliny Earle Chase.

(*Read before the American Philosophical Society, May 16th, 1872.*)

The similarity in the length of day, between the principal and subordinate planets, both in the intra and the extra-asteroidal belt, is so obvious, that many attempts, of which Kirkwood's is the most satisfactory, have been made to formulate it.

I have long thought that there is some simple explanation for the rotation, as well as for the revolution of the heavenly bodies. My recent investigations of explosive gyration, have yielded some interesting results, which, from their relation to the most important bodies of our system, encourage me to hope for further and more minute developments of a like kind.

1. The sidereal revolution of the Moon : the sidereal rotation of the Earth, nearly : : the equatorial value of g at the Sun : the equatorial value of g at the Earth.

$$27.3669 \div 27.292 = 1.00275.$$

2. The action of terrestrial superficial gravity against a uniform opposing force for a sidereal half-day, would be sufficient to give a velocity equivalent to that of a planet near the Sun's surface.

$43,082g = 261.8164$ miles; $265.5184 : 261.8164 = 1.01414$, which is nearly equal to 1 + the Earth's orbital eccentricity.

3. The action of the superficial gravity of Jupiter for a sidereal half-rotation, would also be sufficient to give a velocity equivalent to that of a planet near the Sun's surface.

$18,863 \times 2.41g = 276.247$; $276.247 : 265.5184 = 1.0406$; which is nearly equal to 1 + Jupiter's orbital eccentricity.

4. The action of solar superficial gravity for a sidereal half-rotation, would give nearly the velocity of light.

$$\tfrac{1}{2} \text{ of } 25.1868 \times 86,400g = 180,465;\ 183,454 : 180,465 = 1.0166.$$

5. The action of terrestrial gravity, near the Earth's surface, for a sidereal year, would also give a velocity equivalent to that of light.

$31,558,150g = 191,792$; $191,792 \div 183,454 = 1.04545$, which is nearly equal to 1 + Jupiter's orbital eccentricity.

6. The orbital radius of Saturn : Mercury's orbital radius, nearly : : time of solar rotation : time of terrestrial rotation.

$$9.53885 : .3871 = 24.642;\ 25.187 \div 24.642 = 1.0221.$$

7. The distance of Neptune from the Sun, is nearly equivalent to one-fourth the orbit of Uranus.

$$\frac{19.182639\pi}{2} \div 30.037 = 1.00233.$$

8. The mass of the Sun : the mass of the Earth, nearly : : cube of Earth's orbital radius : cube of Sun's semi-circumference.

$$(214.86 \div \pi)^3 = 319,894;\ 319,894 \div 314,000 = 1.01878.$$

9. The velocity of planetary revolution at the Sun's surface : velocity of solar rotation, nearly : : Earth's orbital radius : Sun's radius.

$955{,}870 \div 4{,}421.7 = 216.173$; $216.173 \div 214.86 = 1.00613$.

10. The square of Jupiter's orbital radius : square of Earth's orbital radius, nearly : : g at Sun : g at Earth.

$27.292 \div 5.2028^2 = 1.00824$ (Compare No. 1).

ÆTHEREAL DENSITY AND POLARITY.

By Pliny Earle Chase.

(*Read before the American Philosophical Society, May 16th,* 1872.)

If the conditions of equilibrium in a perfectly elastic gas have been disturbed by explosion, in the restoration of equilibrium, the particles will simultaneously rush towards each other, and towards the attractive centre m. If h is the extreme excursion consequent on the explosion, the centre of oscillation of each exploding particle being at $\frac{2h}{3}$, the centre of gyration of its return towards the centre of gaseous mass $\left(\frac{h}{2}\right)$ is at $\frac{5h}{9}$. The centre of gyration of the fall from $\frac{5h}{9}$ to the Earth, is at $\frac{5h}{27}$ above the Earth's surface, or at $r + \frac{5h}{27}$ from the Earth's centre.

If $h : r + \frac{5h}{27}$: : the orbital *vis viva* about a diameter $\frac{5h}{9}$: the *vis viva* which would be communicated by virtual fall through $\frac{5h}{9}$: : 1 : 4, we have $27r = 103h$, ; $\frac{5h}{9} = d' = 577.113$ miles ; $r_{/} = 91{,}345{,}800$ miles ; $\frac{r}{d} = 6.8666$; $\frac{68666}{78666}\sqrt{2gd'} = 6103$ feet per second. The approximation of the estimated velocity of hydrogen (6050, Clausius ; 6055, Joule) to this theoretical velocity, seems to indicate that the elasticity of hydrogen is nearly perfect. The inference is strengthened by the close approximation of my first estimates by flame analysis, to the mean of the best astronomical estimates of the Sun's distance.

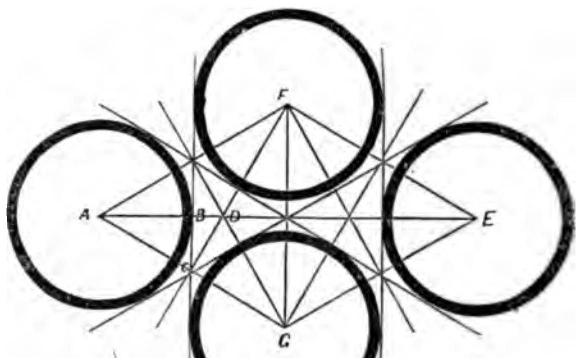
Let d' = density of luminiferous æther ; d'' = density of hydrogen. Calling the velocity of sound in hydrogen 4163 feet, and the velocity of light 183,454 miles, if the elasticities are the same we have the proportion,

$d' : d'' : : 4163^2 : (183{,}454 \times 5280)^2 : : 1 : 54{,}130{,}000{,}000$.

Upon the hypothesis that gravitation is an incidental result of ætherial

elasticity, Professor Norton has found* that "at the distance $80r$ the repulsion becomes very nearly the same for all the assumed values of $\frac{n}{m}$;" n and m being centres of origination for the interior and exterior wave systems of the æthereal atomic envelopes. Now if r = Sun's radius, and r' = Mercury's orbital radius, r' is nearly equivalent to $80r \times (\text{sec. } 30^\circ)^{\frac{1}{3}}$. The second factor may be deduced in the following manner:

If we suppose a collection of spherical atoms of equal magnitude, each of which has condensed around it an æthereal envelope, to be arranged in the most compact manner possible, the lines joining the centres of three contiguous particles will form an equilateral triangle. If the envelope is of such density as to allow the indefinite rectilinear transmission of waves between adjacent particles, one-half the distance between the centres of two adjacent atoms, will be a mean proportional between the radius of the atom and the distance between an atomic centre and an adjacent æthereal centre; the ratio of the atomic radius to the half-distance, and of the half-distance to the inter-central distance, being each equal to the ratio of radius to sec. 30°. In the accompanying figure,



AB : AC :: AC : AD :: rad. : sec. 30° :: 1 : $\sqrt{1.25}$.

According to the hypothesis of Mossotti, that the æthereal particles are infinitesimal in proportion to the atoms, the sphericity of the atomic surface may be disregarded, and the virtual radius of the æthereally-enveloped atom may be supposed to vary as the mass. But in atoms of

* Amer. Jour. Sci., May, 1872, p. 340.

uniform density, $r \propto m^{\frac{1}{3}}$, therefore it need not surprise us if we find in different relations of cosmical masses, the three factors, sec. 30°, $(\text{sec. } 30°)^{\frac{1}{2}}$, $(\text{sec. } 30°)^{\frac{1}{3}}$.

1. Mercury's orbital radius being, as I have said, $r' = 80r \times (\text{sec. } 30°)^{\frac{1}{3}}$. Neptune's orbital radius is $80^2 r$, or $80r' \div (\text{sec. } 30°)^{\frac{1}{3}}$.

$$[80r \times (\text{sec. } 30°)^{\frac{1}{3}}] \div (.3870987 \times 214.86r) = 1.00126.$$
$$(30.03697 \times 214.86r) \div 6400r = 1.0084.$$

2. The distance of the exterior orbital limit of the asteroidal belt (Cybele) is nearly a mean proportional between the distances of Mercury and Neptune.

$$(.3870987 \times 30.03697)^{\frac{1}{2}} : 3.4205 = 1.003115.$$

3. If the Moon's mass is $\frac{1}{83.032}$ of the Earth's mass, her distance is analogous to that of Mercury, being $80 \times (\text{sec. } 30°)^{\frac{1}{3}} \times$ the distance of the Earth's centre, from the centre of gravity of the terrestrial-lunar system. The mean of five recent estimates of the Moon's mass, given by Denison, is $\frac{1}{83.127}$.

$$83.127 : 83.032 = 1.001156.$$

4. The year of Mercury : Neptune's year : : the velocity of a planet near the Sun's surface : the velocity of light, or nearly : : sec. $30° \times$ the mass of the planetary system : the mass of the Sun.

$$(60126.72 \div 87.969258) : (183,454 \div 265.5184) = 1.01088.$$
$$(60126.72 \times \text{sec. } 30°) \div (87.969258 \times 759.46) = 1.00617.$$

5. Venus may be regarded as an exterior satellite of the Earth, at a limit analogous to that of the solar system. For $80^2 \times$ Earth's radius nearly = Venus's distance at perigee.

$$80^2 \times 3962.818 = 25,362,050;\ 25,362,050 \div 25,268,000 = 1.0037.$$

6. The year of Uranus divided by $(\text{sec. } 30°)^{\frac{1}{3}}$, is equivalent to the month of a terrestrial satellite near the perigee distance of Venus (omitting considerations dependent upon solar acceleration and satellite-mass).

$$(25,268,000 \div 238,800)^{\frac{3}{2}} \times 27.32166 \times (\text{sec. } 30°)^{\frac{1}{3}} \div 30,686.821 = 1.006.$$

7. The mass of the intra-asteroidal planets : the mass of all the planets, nearly : : Sun's radius $\times (\text{sec. } 30°)^{\frac{1}{3}}$: Earth's orbital radius.

$$(63.52 : 13167.12) : [(\text{sec. } 30)^{\frac{1}{3}} : 214.86] = 1.00131.$$

My experiments in the years 1864 and 1865,* the most important of which were repeated before the Society, demonstrated that the simple mechanical action, of such elastic vibrations as are excited by the conjoint influence of solar radiation and terrestrial rotation, would not only produce polarity in a needle susceptible of similar vibrations, but it

* Proc. Amer. Philos. Soc. ix., 359; x., 151 sqq.

would also cause such daily and annual fluctuations as those of the magnetic needle. Professor Norton says* that "no conception has hitherto been formed of possible atomic movements capable of originating the electric forces, and producing even the simplest of the electrical phenomena." The dependence of the polarity of the compass upon electrical currents encourages the belief that all the "possible atomic movements capable of originating the electric forces," may be traceable to some arrangement of elastic ætherreal particles like the one I have above suggested. The mutual attraction of the atoms A and E is only one-third as great as that of the atoms F and G, and under the influence of centrifugal force, the several lozenges AFEG would yield most readily in the direction EG.

THE SUN-SPOT CYCLE OF 11.07 YEARS.

By Pliny Earle Chase.

(*Read before the American Philosophical Society, May 16th, 1872.*)

The most recent and careful discussion of the observations upon the [illegible]e amount and frequency of Sun-spots, by De La Rue, Stewart and Loewy,† assigns to the principal cycle a duration of 11.07 years. Kirkwood (ante, vol. xi., p. 100) had previously given nearly the same estimate (11.072 years). If the spots are attributable to disturbances produced by gravitating action, the major axis of the revolving disturbing force should be $[(11.07 : 11.862)^{\frac{2}{3}}] = .955 \times$ Jupiter's, or $4.969 \times$ the Earth's major axis. The mean radius vector of perturbation is, therefore, nearly equivalent to Jupiter's mean perihelion distance ($.95184$ ♃, or 4.952 ⊕) as well as to the mean distance of the centre of gyration of the planetary sytem.

$$\tfrac{2}{3} \times [(3\tfrac{1}{3} \times .3871 + 25 \times .7233 + 31.85 \times 1 + 3\tfrac{1}{3} \times 1.5237 + 9307 \times 5.2028 + 2847.4 \times 9.5389 + 416.7 \times 19.1826 + 532.5 \times 30.037) : (3\tfrac{1}{3} + 25 + 31.85 + 3\tfrac{1}{3} + 9307 + 2847.4 + 416.7 + 532.5)] = 5.101;\ 5.101 : 4.969 = 1.0265;\ 4.969 : 4.952 = 1.0035.$$

The theoretical mean excursion between Jupiter's perihelion and his mean distance, corresponds very nearly with the above valne of the planetary centre of gyration.

$$4.952 + \tfrac{2}{3} \times (5.2028 - 4.952) = 5.091;\ 5.101 : 5.091 = 1.002.$$

If Jupiter's aphelion distance represents the aphelion distance of the aggregate of forces which produce the Sun-spots, the disturbance-perihelion is $(2 \times .955 - 1.048) = .862 \times$ ♃'s, or $4.485 \times$ ⊕'s radius vector. This corresponds very nearly with the linear centre of oscillation, of the mean

* Loc. cit., p. 30.

† Proc. Roy. Soc., Dec. 21, 1871; Phil. Mag., May, 1872.

The ratio $\frac{5}{9}$ is the unit factor for the explosive centres of oscillation of α, β, and γ.

The combined ratios of direct and reverse centres of oscillation, $\frac{4}{9}\times\frac{5}{9}=\frac{20}{81}$, determine the following interesting positions :

Near $9\times\frac{20r}{81}=\frac{20r}{9}$, is the centre of gravity of the solar system, at heliocentric conjunction*. . . . . ν

Near $9^2\times\frac{20r}{81}=20r$, is the centre of explosive oscillation, between the limit of solar retardation and the Sun's surface. . . . . ξ

Near $9^3\times\frac{20r}{81}=180r$, is the centre of gravity of Mercury, Venus, and the Earth. . . . . o

Near $9^4\times\frac{20r}{81}=1620r$, is the centre of gravity of the planetary system. π

Near $9^5\times\frac{20r}{81}=14580r$, is a point which I will designate as the *reciprocal of gravity* for the solar system. . . . . ρ

If the centre of explosive gyration from the Sun to Neptune be taken as a unit, and a point at a distance of 9 of those units $=32805r$ be regarded as the seat of a new explosive action, the point ρ is near the centre of explosive gyration *towards the solar system*. If the centripetal is equal to the radial or centrifugal action, and if gravity is a resultant of æthereal oscillation, the square of the periodic time being 32 times as great as the square of the time of fall to an attracting centre, the modulus of light, relatively to the Sun, should be $32\times\frac{4}{9}\times32805r=466560r$. . . . . . ς

The closeness of this estimate is shown by the following calculation :

log.	c^2	10.527057†
"	g at Sun	$\bar{1}.219737$
"	light mod.	11.307320
"	r	5.628452
"	mod. $\div r$	5.678868

$\therefore$ modulus of light $=477384.6r$.

The half-modulus is the height of virtual fall required, during orbital revolution at the Sun's surface, to acquire the velocity of light, if there were no æthereal resistance. Its relation to three cardinal positions in our system, is expressed in the following proportion :

$\frac{1}{2}$ modulus : ♃'s rad. vec. : : ⊕'s rad. vec. : ☉'s rad.

The approximate value of the Earth's radius vector, as thus determined, is $213.54r$. . . . . τ

* Whenever I have occasion, in the present paper, to speak of the centre of gravity of two or more planets, they will be considered as in heliocentric conjunction, and at their mean distances from the Sun.

† The values of the astronomical elements are taken from Norton's Astronomy.

The same modulus-ratio is also nearly equivalent to the ratio of the aggregate extra-asteroidal, to the aggregate intra-asteroidal planetary masses . . . . υ

If Mercury be regarded as having its mean distance at a direct explosive centre of oscillation, its perihelion distance is at the reverse explosive centre . . . . φ

The combination $\frac{5}{9}\times\frac{5}{9}=\frac{25}{81}$, furnishes the following planetary positions.

Near $9^3\times\frac{25r}{81}=225r$, is the centre of gravity of the Earth and Mars. χ

Near $9^4\times\frac{25r}{81}=2025r$, is the orbit of Saturn . . . . ψ

The foregoing approximations are embodied in the following synopsis:

TABLE I.

Centrifugal Evidences of Planetary Explosive Oscillation.

	(A) Theoretical.	(B) Observed.	(B—A)÷A.	Basis.
α	81.	83.17	.027	9^2
β	729.	734.93	.008	9^3
γ	6561.	6453.73	—.016	9^4
δ	.3333	.3149	—.055	$\frac{1}{3}$
ε	.6667	.6563	—.016	$\frac{2}{3}$
ζ	.5	.4973	—.005	$\frac{1}{2}$
η	.4444	.4705	.059	$\frac{4}{9}$
θ	.4444	.4371	—.016	$\frac{4}{9}$
ι	.5556	.5454	—.018	$\frac{5}{9}$
κ	36.	36.96	.027	$\frac{4}{9}\times 9^2$
λ	324.	326.59	.008	$\frac{4}{9}\times 9^3$
μ	2916.	2970.43	.019	$\frac{4}{9}\times 9^4$
ν	2.2222	2.17	—.025	$\frac{4}{9}\times\frac{5}{9}\times 9$
ξ	20.	20.43	.022	$\frac{4}{9}\times\frac{5}{9}\times 9^{[illegible]}$
o	180.	182.83	.016	$\frac{4}{9}\times\frac{5}{9}\times 9^{[illegible]}$
π	1620.	1625.69	.004	$\frac{4}{9}\times\frac{5}{9}\times$ [illegible]
ρ	14580.	14341.64	—.016	$\frac{4}{9}\times\frac{5}{9}\times$ [illegible]
ς	466560.	477384.6	.023	32 [illegible]
τ	213.54	214.86	.006	
υ	213.54	206.29	.034	
φ	.8	.7945	—.007	$\frac{4}{5}$ [illegible]
χ	225.	225.46	.002	$\frac{5}{9}\times\frac{5}{9}$ [illegible]
ψ	2025.	2049.51	.01	$\frac{5}{9}\times\frac{5}{9}$ [illegible]

The importance of combining the centres of direct and reverse explo[illegible] gyration, in forming the units of the series which is to contain [illegible] modulus of equal universal action and reaction, is obvious.

Reversing our procedure, and commencing at the centre of oscillation of the reciprocal of gravity (α'), we find the following relationships:

$\frac{2}{3}\,\alpha'$ is near the mean position of Neptune............................ β'
$\frac{5}{9}\,\alpha'$ " the c. grav. of Neptune and Uranus........................ γ'
$\frac{5}{9}\,\gamma'$ " " " of Neptune, Uranus and Saturn............... δ'
$\frac{5}{9}\,\delta'$ " " " of the four outer planets....................... ε'
$\frac{2}{3}\,\varepsilon'$ " " mean position of Jupiter..................... ζ'

The centre of linear oscillation, therefore, appears to have had an important influence in determining the positions of Neptune and Jupiter, and the centre of explosive oscillation in fixing the places of the intermediate planets. Neptune's position is also near the reverse centre of explosive oscillation of the reciprocal of gravity, $\frac{2}{3}$ of $\frac{5}{6}$ being equivalent to $\frac{5}{9}$.

From the excess of the observed over the theoretical value of the modulus of light (ρ), in the foregoing table, as well as from the fact that the theoretical modulus best satisfies the hypothesis of explosive positions in the outer planetary system, I infer that the mean velocity of light between Neptune and the Sun, is retarded a little more than one per cent. by the condensation of æther towards the Sun.

$\frac{5}{9}\,\zeta'$ is near the centre of gravity of the principal asteroids, and also near the centre of explosive oscillation from Cybele to Flora...... η'
$\frac{5}{9}\,\eta'$ is near the mean position of Mars.............................. θ'
$\frac{5}{9}\,\theta'$ is near the centre of gravity of the three interior planets.......... ι'
$\frac{5}{9}\,\iota'$ is near the linear centre of oscillation of Venus................. κ'
$\frac{5}{9}\,\kappa'$ is near Mercury's perihelion.................................... λ'
$\frac{5}{9}\,\lambda'$ is near the explosive centre of gyration, which limits solar atmospheric retardation.. μ'

This second series of coincidences is grouped in the following table:

TABLE II.

Centripetal Evidences of Explosive Oscillation.

	(A) Theoretical.	(B) Observed.	(A–B) ÷ A	Basis.
α'	9720			$\frac{1}{45}$ modulus.
β'	6480	6453.72	.004	$\frac{2}{3}\alpha'$
γ'	5400	5429.62	–.005	$\frac{5}{9}\alpha'$
δ'	3000	2894.57	.035	$\frac{5}{9}\gamma'$
ε'	1633.33	1632.69	.000	$\frac{5}{9}\delta'$
ζ'	1088.89	1117.87	–.027	$\frac{2}{3}\varepsilon'$
η'	604.94	588.07*	.028	$\frac{5}{9}\zeta'$
	"	589.41	.026	"
θ'	336.08	326.59	.029	$\frac{5}{9}$
ι'	186.71	182.83	.021	$\frac{5}{9}\theta'$
κ'	103.73	103.61	.001	$\frac{5}{9}\iota'$
λ'	57.63	56.07	.027	$\frac{5}{9}\kappa'$
μ'	32.02	32.36†	–.011	$\frac{5}{9}\lambda'$

* Mean radius vector of Juno, Ceres, and Pallas.

† $\frac{8}{9}$ of 36.4; 36.4 being the mean of the two extreme values, derived from Sporer's and Hornstein's estimates.

$$\rho' = \tfrac{5}{6} \times (\tfrac{3}{2})^9 \times r$$

$$\rho' : r = \text{modulus of light} : \rho = 7^2 : 6^2$$

There are, therefore, NINE principal planetary orbital divisions, determined mainly by centres of explosive gyration; NINE successive centres of linear oscillation between the modulus of light and the reciprocal of gravity: NINE similar centres between the limit of the Sun's possible atmosphere and the Sun's surface; and finally, NINE successive powers of NINE, that exert important centrifugal determinations. For we find:

At $9^{-3}r$ the fulcrum of the solar system, if the planetary masses were concentrated in a point at r.

At $9^{-2}r$ is the seat of an explosive oscillation, which would tend to detach a nebulous ring, with a mass $9^{-3}m$, provided the centre of oscillation of the ring were at the present geometrical planetary mean, $9^{-3}r$. For, in order that the separation should begin, the velocity of nebular rotation at the surface of the central body should bear such proportion to the mean velocity of revolution in the ring as the radius of the central mass to the radius of the ring's centre of oscillation, and as the velocity of virtual revolution at the central surface, to the like velocity at the seat of explosion, $(1 : 81^{\frac{4}{3}})$

At $9^{-1}r$, a planetary mass which was in nebulous condition in the above ase, having acquired sufficient central condensation for the detachment of an interior planet, would have its fulcrum at the Sun's surface, if its centre of gravity were at the distance of Mercury. The combined effect of these two primitive hypothetical breaks is perhaps recorded in the solar rotation, which occupies nearly, if not *precisely*, $\frac{5}{9} \cdot \frac{1}{3} \times 729$, × the planetary orbital time at the Sun's surface.

At $9^0 r$ is the Sun's surface, the probable seat of many of the explotions which have lately attracted so much attention.

At NINE r, is the first theoretical exterior limit of explosion, in which she Sun is central and its opposite surfaces are centres of alternate direct and reverse explosive oscillation. Here is, perhaps, the limit of an important solar envelope.

Near NINE times the first exterior limit, or 9^2r, is the orbit of Mercury.

Near NINE times the second exterior limit, or 9^3r, is the asteroidal limit.

Near NINE times the third exterior limit, or 9^4r, is the orbit of Neptune.

Near NINE times the fourth exterior limit, or 9^5r, is the centre of Sunward explosive oscillation which determines the reciprocal of gravity.

Such considerations, conjoined with the observed increase of spotted surface on the side of the Sun next the Earth and most remote from other disturbing planets,* seem to furnish a clue to the solution of the Sun-spot mystery. Even if all the planets were so arranged as to be either in mutual heliocentric conjunction or opposition, their combine

* De La Rue, Stewart and Loewy, *Proc. Roy. Soc.*, xx., 210, *sqq.*

influence would not suffice to raise a tide of a quarter-inch at the Sun's surface. But variations of inertia ($m\ d^2$) and of power to produce local oscillations $\left(\frac{m}{d^2}\right)$ may be much more important, in their influence on fluid bodies, than differential tidal variations $\left(\frac{m}{d^3}\right)$. At the very outset of my cosmical investigations (*ante*, ix., 287), I gave a method for estimating the Sun's distance by comparing the atmospheric inertia relatively to the Earth, with the same inertia relatively to the Sun. The remarkable coincidence of the disturbing focus of the Wolfian cycle with the centre of linear oscillation in the planetary system, seems to render it probable that solar explosions and spots are also determined by laws of inertia and local oscillation.

ON BATHMODON, AN EXTINCT GENUS OF UNGULATES.

By Edward D. Cope.

(*Read before the American Philosophical Society, Feb.* 16, 1872.)

The present form embraces some of the largest Perissodactyles, or odd-toed Ungulata, of our Tertiary Strata. It is represented by remains of two species, which include portions of the cranium, with teeth and fragments of jaws; vertebræ, fragments of scapular and pelvic arches and bones of the limbs. The distal end of the tibia is wanting, but that of the fibula indicates an odd-toed animal, and the third trochanter on the exterior ridge of the femur confirms the reference.

There are probably four superior molars, though three only are preserved. Two premolars only remain of the superior species, but the fragment of ramus mandibuli, referred to the same species, exhibits four premolars; from a consideration of the sizes of the superior premolars it is probable that there were four of these also. There are three strong incisors in each premaxillary. No canine tooth is preserved, but the posterior suture of the premaxillary bone is so wide as to point to an equally stout anterior part of the maxillary, fitted to support such a tooth. The dental series increases regularly in size, from before backwards, the last being a little larger than the penultimate. The crowns of the molars exhibit on the outer margin a single, acutely-angled crescent, directed inwards, with a conic lobe alongside of, and anterior to its base, representing a second external crescent. The crescent lobe proper is large and very obliquely directed, so that its external face is almost horizontal. The apex of its companion cone is continuous with its posterior margin, so as to be undistinguishable from it in some cases. The inner crescents are represented by a wide angular ridge, which is at a lower level than the exterior, and is little or not developed on the posterior side of the crown.

Its inner-plane face is horizontal, or even ascending in one species. In the premolar teeth of *B. radians*, the external crescent lobe is single and symmetrical. As the crown contracts inwardly, a second inner crescent lobe has a trihedral form, while in one more anterior, the inner is much reduced. The inferior premolars are all two-rooted, and form an uninterrupted series. The basis of the molar part of the zygomatic arch originates opposite the adjacent parts of the penultimate and last molars. The premaxillary bone is massive, and with but little area for attachment with its fellow in front. The incisor teeth are large, with subcylindric roots, and their alveoli are well separated. In one, perhaps superior, the crown is expanded transversely, with convex cutting edge.

In the *humerus*, the deltoid hook is developed, but is not much elevated above the plane of the head. It originates from an external expansion of the head, which bears a shallow cotylus, separated from the head by a low, curved, subtransverse ridge. The condyles of the humerus do not support any trochlear ridges. An almost perfect femur of *B. radians* is preserved. The third trochanter is not very prominent. The little trochanter is little developed; the great trochanter is large but does not equal the head. The latter is subglobular, and the ligamentous fossa extends to its rim. The distal trochlear surface is prominent, the inner edge more so than the outer. Its articular surface is broadly continuous with those of the condyles; a slight emargination of the outlines only marking the usual constriction on each side. In this it resembles *Cervidæ* and some *Antilopidæ*. The inner condyloid surface is cut off by the emargination in *Toxogen* and *Bos bubalus*; the emarginations are deep, but do not cut off either in *Equus*, *Camelopardalis* and three species of *Bos*; while they are so deep as to cut off both in *Rhinoceros*, 5 sp., *Hippopotamus*, *Bos brachyceerus*, *B. sondaicus* and *B. sebyniceerus* and in *Catoblepas*.

BATHMODON RADIANS. Cope. Sp. nov.

Represented by portions of several individuals, which indicate an animal varying from the size of the ox to that of the Javan Rhinoceros.

The transverse diameters of all the molars exceed their longitudinal. In the penultimate, which may serve as a type, the superior or outer plane of the inner crescent ridge extends along about .66 of the posterior of the outer crescent. In the last molar this surface is very wide on the posterior and inner side of the external crescent: it then contracts, and expands again on the posterior side, its outer bounding crest reaching to the external margin of the crown.

Besides these points, the molars possess a strong cingulum along the anterior base of the crown, which unites with the surface near the inner proturberance of the latter in the penultimate: in the last molar it reappears, forming a short lobe on the posterior face. The enamel where not worn is slightly rugose.

A posterior premolar has a cingulum on the inner obtuse apex. The crest of the inner crescent, descending on each side of the apex of the

outer, forms a cingulum-like ledge at its base as far as the angle formed by the descent of the apex of the outer crescent. The outline of the corner of this tooth, viewed from above, is narrow cordate, with obtuse apex. The convexity of the outer crescent inwards is very strong, and the base of the crown is externally two-lobed. Enamel striate rugose. In a more anterior premolar (with three roots) there is no internal cingulum, and the crest of the inner crescent is not carried to the external basis of the tooth, and is entirely wanting on the posterior face of the tooth. The external crescent is more vertical and less concave. Outline of crown subtriangular.

The premaxillary bone is elongate, flat, and with a sloping superior face, which rises gently inwards. The bases of the incisors stand obliquely outwards. The inferior surface is flat, and the basis of the broken palatal spine is rather small. An incisor tooth has a transversely diamond-shaped crown, slightly twice concave on the inner face, strongly convex on the outer, with a faint external cingulum near the external angles. Enamel obsoletely striate.

MEASUREMENTS. (NO. 1.)

	M.
Longitudinal diameter last superior molar	.035
Transverse " "	.0455
Longitudinal " penultimate	.032
Transverse " "	.039
Longitudinal " posterior premolar	.024
Transverse " "	.034
Longitudinal " anterior "	.0215
Transverse " " "	.0265
Length premaxillary bone	.082
Transverse width posterior suture	.028
Width premaxillary at middle "	.043
Length basis last two inferior premolars	.057
Transverse diameter edge of mandible at first premolar	.017
Diameter condyles of femur	.104
" heads great trochanter	.130
" head alone	.062
" shaft with third trochanter	.076
Supposed length femur (16.75) inches	.415
Transverse diameter head of tibia	.092
Antero-posterior " internal	.061
" " external	.045
(?) No. 2.	
Longitudinal diameter head of humerus	.138
" " of outer cotylus and tuberosity	.055

The other remains of this animal will be more fully described and the whole figured, shortly. They were discovered by Dr. F. V. Hayden, in tertiary beds of the Wahsatch Group, near Evanston, Utah.

BATHMODON SEMICINCTUS. Cope. Sp. nov.

This species differs from the last in several particulars of dentition. The interior ridge (homologous with the inner crescentic) bounding the middle plane of the superior molars, is not continued on the posterior face of the tooth, but curving inwards joins the outer crest at its apex. The outer crest terminates in a conic tubercle anteriorly on the external face, the rudiment of the anterior crescentic ridge appearing as a low ridge from the side of the posterior one, and rising to a point on the anterior margin of the crown. There is no cingulum round the anterior base of the crown. The latter is as long as wide. The inner crest is reduced to a mere angle, and its posterior face is not basin-shaped but rises to the crest of the inner crescent. The outer face of the latter is sub-horizontal with rising apex, and is concave transversely. Its anterior outer base is narrowed but is less elevated than the posterior.

Measurements.	M.
Length basis crown	.0225
Width "	.022
" exterior crescent	.012
Depth " "	.02

This animal was not more than half the bulk of the last; its size was about that of the *Tapirus terrestris*. The differences in dentition which it presents are so marked as compared with the last species, as to induce me to believe that it will be found on fuller acquaintance to belong to another genus. This may be called *Loxolophodon*. Other remains belonging to these species, or relating to it in size, are contained in Dr. Hayden's collection, but cannot now be referred to with certainty.

From the Wahsatch Beds, near Evanston, Utah.

Especial interest attaches to these fossils from the fact that, they belong to the oldest of the tertiary periods of North America. The Wahsatch Group, according to Dr. Hayden, underlies the Bridger Group, which has yielded so many mammalian species to the researches of Leidy and Marsh. These have been supposed to be Eocene, so that the age and species here described is not later than that. The character presented by the molar teeth are very peculiar, and indicate not only a new genus, but a new family. This has a remote affinity only to the group of *Palæosyops*. *Titanotherium, etc.*

ON TWO NEW ORNITHOSAURIANS FROM KANSAS.

BY EDWARD D. COPE.

(*Read before the American Philosophical Society, March* 1, 1872.)

The species about to be described resemble, in their large proportions, the large pterodactyles of the English chalk and green sand. The specimens at my disposal consist chiefly of portions of the anterior limb, of metacarpals and phalanges. Some of the phalanges of the claw-bearing digits are remarkable for their relatively large diameter, a peculiarity

stated by Seeley to be found in the species of his genus *Ornithochirus*. As it is not likely on other grounds that the species of the Niobrara cretaceous strata belong to the genus *Pterodactylus* of Cuvier, which is chiefly known from the Jurassic period, I place the Kansas species for the present in *Ornithochirus*, as established by Seeley.

Ornithochirus umbrosus. Cope.

Represented by the distal portion (ten inches) of the wing finger metacarpal; the proximal portion (eight inches) of the first phalange of the same digit, with two phalanges of claw-bearing digits. The distal condyles of the first named bone are separated by the usual deep groove above and below, and wind separately to their terminations on the inferior face. The narrow base which supports the inner condyle is bounded posteriorly by an acute edge; directly outside of the base of this ridge is a deep groove or foramen, which is bounded next the external condyle by another ridge which rises to the base of the inner condyle on the trochlear side. The transverse diameter of the condyle is M. 0.043 or 17 lines.

The proximal end of the first phalange is perfect, but flattened by pressure. It presents the two usual cotyloid cavities well separated by an elevated ridge. Anteriorly, it presents an elevated crest for muscular insertion. This terminates abruptly, and is followed distally by a deep notch. Distal to this is another prominence of the bone also probably an insertion. Antero-posterior diameter (flattened), 24 lines.

The claw phalange is short and wide; both its articulations are simple and concave. Both outlines are keeled, one very strongly at one end, and at the other presenting beyond the articular surface, a wide prolonged process for muscular insertion. Length phalange without process, thirteen lines; process, four lines; diameter, widest extremity, eleven lines. This indicates a very stout digit. The other digit is penultimate, and is remarkable for its small size, perhaps indicating an external rudimental digit. It is only supposed to belong to the anterior limb, from its having been found with the preceding bones. It is more slender than the other, and differs in having convex distal articulation, divided by a trochlear groove, and the concave proximal one in like manner divided by a trochlear carina. Length, nine lines; proximal depth, three lines.

This species is the largest Pterodactyle as yet known found on our continent, the end of the wing metacarpal exceeding in diameter that of the species described by Professor Marsh, from the same region, by 4. lines.

From near Butte Creek, from the yellow chalk.

Ornithochirus harpyia. Cope.

Established on wing metacarpals and phalanges of three individuals. The articular extremities indicate a species from one-half to two-thirds the size of the last named. Those of the metacarpal are very prominent above as well as below, and there is no distinct ridge in the trochlear groove between them. The inner condyle does not stand on a base with an acute posterior ridge, but overhangs a rather obtusely-edged support.

There is no second ridge on the outer (trochlear) side of it. The same condyle terminates abruptly posteriorly on the superior face of the shaft. Width of condyles in No. 1, eleven lines; in No. 2, thirteen lines; vertical diameter, inner condyle, eleven lines (No. 1); transverse diameter shaft above, eight lines.

The proximal articular surfaces of the proximal wing phalanges are deeply concave, the inner protected by an elevated margin behind; that of the outer, much lower. They are separated chiefly by a deep emargination, but on their short adjacent portions by a low ridge. The process for ligamentous insertion is well developed. The distal extremity is slightly widened, and its articular surface is wedge shaped with very convex base. Its surface is slightly concave in both directions and without median ridge. The margin of the shaft terminates in a short tuberosity bearing articular surface. Transverse diameter, sixteen lines. Length of shaft preserved, but incomplete, nine inches, one line.

This species is about the size of the Pterodactyle found by Professor Marsh in the same region,* and probably belongs to the same genus, and possibly to the same species. This, however, cannot be definitely ascertained as his species is imperfectly described, all the characters adduced except the measurement being generic. The name given by Professor Marsh has also been previously used, both in this genus and in *Pterodactylus*, and must therefore be given up.

Remains of the two *Ornithochiri* above described are not rare in the yellow chalk of the Niobrara Group, and those obtained were mostly from different parts of the course of the bluffs of Butte Creek.

A DESCRIPTION OF THE GENUS PROTOSTEGA, A FORM OF EXTINCT TESTUDINATA.

By Edward D. Cope.

(*Read before the American Philosophical Society, March 1st, 1872.*)

The present article introduces to the system a new form of Testudinata of a character not heretofore found in a fossil condition. Its affinities will be more fully discussed at the end of the description, but they appear to belong to the *Sphargidida*. This family is represented, in our present knowledge, by but one genus and one species of the recent seas. It is one of the most generalized, or in special characters, the most aberrant of the order of the tortoises, and the discovery of an extinct ally, even as far down in the series as the cretaceous period, is not surprising.

The remains preserved belong to a single individual, and include many portions of the cranium, five vertebræ more or less incomplete, the scapular arches of both sides with the coracoid bones; both humeri perfect, with nine phalanges, ten ribs, one vertebral (?), and ten marginal bones; parts or wholes of four large lateral (?) dermal bones, with five distinct

*See Am. Jour. Sci. Arts, June, 1871.

bones of unknown reference. There are also some slender curved bones which probably pertain to the plastron.

As the bones were exposed by excavations in the yellow cretaceous chalk, sketches of their positions and relations were made, which aid materially in the restoration of the animal. The upper layer of bones were those of most irregular form, as cranial and limb bones. Mingled with these, but often beneath them, were the ribs, while underlying all, were the large flat pieces here described as dermal. Adhering to the inferior surface of these was a layer of thin oyster shells with parallel striate surface, perhaps *Inocerami*. The ribs presented their heads upwards; so that taking all points into consideration, there is little doubt that the reptile was entombed on its back.

The texture of the bones is peculiar. There are nowhere to be seen medullary cavities, and the bone is spongy, but very finely so, the tubules at the largest being equal in diameter to an ordinary pin, and generally considerably smaller. They are arranged in concentric series. There is no thick dense layer of the bone as in other tortoises, but an extremely thin one, which is hard and sculptured on the surface with minute grooves or pits. The tissue of the bone is very fragile, and has a fracture like the mineral enclosing it. Many of the bones, especially those of the dermal skeleton, are extremely attenuated on the margins, being no thicker than writing paper.

There are twelve *marginal bones*. They are all characterized by their laminar form. The thinnest are those furthest removed from the middle of the sides. They consist of a single lamina slightly thickened within the margin, producing a slight convexity of the lower side. The proximal part of the bone is an extremely thin plate with radiating ossification, and consequently more or less serrate margin. It extends some distance over the extremity of the rib, whose apex is received into a half pit or acuminate groove with abrupt termination, about one-sixth the width of the bone from the margin.

In following the marginals to the middle of the side, the edge, as usual, increases in thickness. The lower side becomes more convex, and the upper slightly concave. The edge is acute, and a very open interior entering angle at the middle. The lateral extremities of the marginals are irregular, terminating in a double series of closely packed digitations, which terminate freely, and enter into no suture. The pit receiving the extremity of the rib approaches the margin, which now develops an inferior lamina of bone. This encloses the end of the rib, and thins out laterally in contact with the superior plate. At first the inner lamina is short; later it is almost as extensive as the outer part of the marginal plate, causing the double appearance when fractured. As the marginals thicken, a distinct inferior plane becomes distinguished, separated from the interior face by an obtuse angle. The upper face near the margin is more concave. In the thickest and inferior face is also somewhat concave, and the edge quite acute. The lateral extremities consist as before of packages of digitations which easily break out.

A single nearly bi-lateral bone of this series appear to be either nuchal or caudal, but as it has no sutural connection with any other it is not easy to determine which is. Its marginal length is much less than its transverse extent, which consists chiefly of a flat lamina. The marginal part is a little thickened and bi-laterally concave below, and correspondingly convex above. The margin is thin and acute. A few grooves radiate at a distance from the middle towards the margin. The lack of concave excavation of the margin would incline the balance in favor of the view that this bone is the caudal.

A very long gently curved bone is probably the marginal extending on one side of the nuchal. It is nearly twice as long as the others, and has an extensive and thin superior lamina. Its (?) anterior part is in one plane, but the margin soon thickens and displays a rather wide infero-external face. It appears to have had an inferior lamina on its posterior half, which made an angle with the face just described. An oval cavity included, looks as though designed for the apex of the rib.

The variation in the lengths of these marginal bones is noteworthy. I give measurements, premising that a few lines may be added to the extremities of some for lost digitations:

	M.
Length of long anterior (11 in.)	0.28
Width " " (some lost)	.135
Length of lateral with inferior face	.195
Width " (much lost)	.110
Length " with narrower inferior face	.206
Width " (much lost)	.115
Length of one with interior lamina	.14
Width " (some lost)	.086
Length of a thinner, no inferior plate	.193
Length still thinner, " "	.182
Width of " (broken)	.137
Length thinnest	.162
Width " (nearly complete)	.160
(?) Caudal length	.117
" width	.150

The shortness of the marginal with large interior lamina is noticeable, as also the same peculiarity in the caudal. As compared with marine turtles, difference is to be observed in every particular. Such are the lack of sutural union, the laminar character; the great extent of the superior and distinctness of lower laminæ. There is no trace of epidermal sutures visible anywhere.

A single symmetrical plate appears to have belonged to the middle line of the back or nape. It was sub-triangular in outline, all the margins very thin, and with an obtuse keel extending on the middle line, on the posterior (or anterior) two-thirds to the apex. This ridge disappears in (?) front by a gradual expansion. The surface is marked by lines of minute

pits and grooves, which radiate from the base at the (?) front of the ridge. Length, M. .135; width, .21.

The *lateral dermal bones* preserved, are two entire, and large parts of one or of two others. They have an irregular oval outline and are slightly dished on the inferior surface or that next the ribs. The upper surface is more convex longitudinally, from the thickening of the bone. The margins are irregular from the projection of many digitations. Some of these are broad and flat, others are narrow. They are frequently two deep, and the fissures separating them occasionally extend far towards the middle of the bone. The convexity assumes the form of a low ridge towards one end of the bone. At the point where this reaches the margin, the latter is in all the four plates, thickened, and composed of several layers of packed osseous radii. When found, the ribs laid across these shields; one of them occupying the position of a radius to one of them. These shields are much larger than the marginal bones.

	M.
Length "No. 10" (21 inches)	0.535
Width " (broken)	.400
Thickness at middle	.014
Length "No. 9"	.530
Width " (much broken)	.530
Thickness at the middle	.013

The lengths and breadths given are a little below the truth, owing to the loss of the exceedingly thin margin.

Turning to the endo-skeleton, the *vertebræ* deserve mention. There are more or less complete examples of five of these: in two, both centrum and neural arch; in two, neural arch; and in one, centrum, are preserved. These have been recognized chiefly by their neural arches, which are separate. They are in form something like an X, the extremities of the limbs carrying the zygapophysal surfaces. The only point of contact with the centrum is a wide process which stands beneath the anterior zygapophysis, and spreads out foot-like obliquely forwards and outwards, to beyond the line of its anterior margin. Its surface extends nowhere posterior to the surface of zygapophysis above it, but a little further inwards. Its outer margin rises ridge-like to the under side of the neural arch, and each one forming a semi-circle forms the boundary of the neural canal, and turning outwards forms the *inner* boundary of the posterior or down-looking zygapophyses. The space between these apophyses is roofed over, so as to produce a shallow zygantrum, which, however, only seems to roof over the deep emargination of the neural arch of the vertebra immediately following. The anterior zygapophyses are often broken away, so that the neurapophysial supports look like the missing pair, when the difficulty ensues that both pairs look downwards. The top of the neural arch is in two cases broad and flat; in two others there is an obtuse keel.

The centra apart from their arches are puzzling bodies, especially since

in the present case they are somewhat flattened by pressure. They differ materially in size, one of them being twice the size of the others. The smaller ones are of the ball and socket type and have a deep longitudinal groove on each side. The thicker portion of the centrum forms the inferior boundary of this pit-groove, while a thinner portion, possibly a diapophysis limits it above. It is, however, thin, and had no great length. There is no sign of chevron bones and articulations, so that these vertebræ may have been cervical. Their bodies are, however, shorter and wider than in those vertebræ of any known tortoise. A groove on the upper surface represents the neural canal; while a flat portion on each side in front, supports the neurapophyses. The large centrum exhibits the superior groove, and antero-lateral platform for support of the neural arch. One end is cupped obliquely, while the other is nearly plane, with the same obliquity and a slightly raised margin. Its outline is sub-triangular. The lower side of this centrum possesses a short keel posteriorly. The sides exhibit no pit, but have a thin edge, which is concave behind the middle, and then turn outwards. I can see no articulation for a rib.

The forms and characters of these vertebræ resemble *Sphargis* more than anything yet described. Either the large or the small, or both must be referred to the dorsal region; in this case the concavity of one extremity is a new feature among tortoises, so far as known. The great freedom of the arch from the centrum is very peculiar, while it is probable that the articulations of the ribs were to the middle of the side of the body, and not to the adjacent parts of two bodies, and may have been (see below) to processes or diapophyses.

	M.
Length medium centrum	.037
Width " "	.060
Length between margins of zygapophyses do.	.060
Width " anterior " "	.070
" " posterior " "	.047
" " anterior basis of arch	.070
" arch at middle	.028
Length " "	.040
Width posterior zygapophyses, No. 2	.048
" of arch	.025
Length "	.025
" of anterior foot (oblique)	.02
Length centrum of large one	.06
Width " " "	.094
" neural canal " "	.017

Ten *ribs* were recovered. These are slender and rather flatter than in most reptiles, but without the peculiar form, characteristic of tortoises and turtles. They are most expanded proximally, the bone spreading into a lamina, from the tubercular region, extending laterally and prox-

imally some distance beyond the head. The superior plane of this expansion is continuous with that of the rib, and is flat; the head of the rib therefore turns downwards and inwards from it, to join the vertebra. Now the extent of the inner part of the lamina is such that, were the head articulated to any of the centra discovered, the former would interfere or overlap. They may, therefore, have been articulated to diapophyses. The expansions are serrato-digitate on the margins, and exhibit radiating grooves and ridges in some places, on the superior aspect. The lengths of these ribs are not so great as the proportions of some of the other bones would indicate.

	M.
Length "No. VI." (16 inches)	0.510
Width at head	.140
" of "	.040
" at middle	.055
" at extremity	.040
Length "No. II."	.390
Width " just below the head	.100
" at middle	.037
Length "No. IX."	.380
" proximal to head	.060
Width at middle	.08

In the rib "No. II." the head is turned obliquely to one side, indicating that the rib diverged at a strong angle from the vertebral column, in fact not more than one of 45°. This is then an interior or posterior rib, probably the latter, since the shell is usually expanded chiefly in that direction. All the ribs are flat above, and convex inferiorly.

Both sides of the *scapular arch* are complete, except the sutural portions of coracoid and scapula of one side. The scapula and procoracoid make a very open angle with each other, both being stout; the scapula the longer, with grooved sculpture at its proximal end. The procoracoid is a little the shorter. The glenoid cavity and coracoid suture are almost sessile at the union of the scapula and procoracoid. The coracoids are very elongate, almost equal to the ribs, and not stouter except at the extremity. It is expanded into an oblique head proximally; the shaft is flat, one edge thickened or truncated, the other thin. The distal portion is scarcely expanded, being more slender than in any recent Testudinate known to me.

	M.
Length scapula to glenoid cavity	0.213
Width " proximally	.045
Length procoracoid to articular surface	.106
Width " distally	.060
Length coracoid	.400
Width proximally	.086
" medially	.047
" distally	.080

The elongate coracoid resembles most, among recent Chelonians, the marine genus *Chelone*, while the sessile glenoid cavity and short procoracoid with open angle are entirely different. In these points this genus is more like terrestrial forms as *Testudo*, or less like *Emys*.

Both *humeri* are entirely preserved. They appear to have been somewhat flattened by pressure ; but when unaltered they were no doubt flat, with stout proportions. They have a globular head with an immense trochanter which projects much beyond it proximally. The shaft is there much contracted, and expands again distally to the broad and very convex articular extremity. Opposite the narrow part of the shaft, the small trochanter appears on the inner side, forming an elongate ala. The long axis of the humerus is not straight, the proximal and distal portion making an angle of 110° with each other.

	M.
Total length humerus (1 ft.) straight	0.300
Length " from head	.296
Width at head	.156
" of "	.073
Least width shaft	.076
Greatest distal width	.132
Length basis little trochanter	.080
Thickness at shaft	.031

The flatness of this element and situation of the large trochanter in the general plane are characters of the *Sphargididæ* ; the great constriction medially and expansion of both extremities remind one of the *Mosasauroid* humerus.

Of bones of the fore arm there may be one, but the bones next in size to the humerus look more like metacarpals or metatarsals. Two of them were found together in position and their relative positions were not like those seen in the fore-arm of sea-turtles. They measure over seven inches in length, and are strongly concave on their adjacent sides. One of them is slightly concave on the outer side, the other convex, the convexity being at $\frac{2}{3}$ the length from one end. The ends of both are a little expanded and one end of one displays a double or trochlear extremity. The same end of the other is injured by pressure. A still larger metacarpal-like bone is relatively more expanded at the ends. The articular surface of one of these is wide at one end, and much narrowed at the other. The smaller bones, undoubtedly phalanges, are six in number. They are quite slender, a little expanded at the ends, and flat.

	M.
Length largest	0.165
Width do. at extremity	.065
" " middle	.032
Length longest of pair	.180
Width, extremity	.050
" shaft	.027

	M.
Length phalange	.032
Width, extremity	.032
" shaft	.018
Thickness shaft	.011

These measurements indicate for the fore limb a total length of 4.52 feet (M. 1.347) if proportioned as in *Chelone*; this would give an expanse of 11.3 feet. If, however, it was constructed on the plan of *Sphargis*, the expanse would be nearly seventeen feet.

Several instructive *cranial bones* were preserved. These are the maxillary and distal part of the dentary of the left side; the posterior part of the left mandibular ramus; quadrate bones and adjacent pterygoids and squamosal, one side with the columellar plate also; right post-orbital bone and part of the left. Also some probably hyoid elements.

The *maxillary bone* and dentary present a considerable extent of the alveolar margin. This is remarkable in being thin, sharp and elevated, without horizontal portion. The former bone is but little incurved to the premaxillary suture; its anterior outline is elevated and vertical, the nostrils entering opposite the probable middle of the orbit. The palatal plate of the maxillary has no great antero-posterior extent, so that the inner nares are opposite the anterior part of the orbit. The latter presents only the anterior and inferior outlines in the specimen. The part of the maxillary below it is very narrow, and weaker than either *Sphargis* or *Chelone*. The cutting edge has a very open sigmoid flexure, suborbital part being turned inwards, the anterior part a little outwards. The osseous rim of the orbit projected considerably beyond the plane of the maxillary anteriorly.

The *dentary* bone is very deep anteriorly, and like the maxillary is a thin vertical lamina. The lower anterior angle is truncated by an acute concave margin. This is the anterior extremity of the symphysis. This suture occupies the inner face of a triangular area which extends but a short distance on the lower margin of the ramus, and then passes upwards and backwards for a short distance on the inner face of the ramus. That portion above the symphysis diverges outwards, thus producing a deep notch at the symphysis, as though designed to receive a beak-like projection of the premaxillaries. The cutting edge has a slight sigmoid flexure corresponding with that of the maxillary; it rises into a projecting angle.

The posterior part of the ramus displays the cotylus, and in front of it a deep long fossa behind the articular bone. There is no angle nor coronoid bone, as in all marine turtles. The superior margin of the *dentary* is thicker posteriorly than in front, and its outer wall is produced backward as a thin lamina, covering the surangular almost to the posterior end of the ramus. The *angular* is, as in recent forms, a narrow wedge-shaped piece below the dentary and surangular. The posterior edge of the surangular projects behind the dentary and exhibits an acute convex

edge rising forward. It supports a small part of the articular cotylus on its inner face. Most of this portion occupies the extremity of the *articular*. The latter sends a stout lamina obliquely upwards and forwards to the lower posterior part of the dentary.

The *quadrate bones* are of a peculiar form. They exhibit the usual posterior curviture above, with shallow funnel-like fossa for the tympanic cavity. It presents two strong ridges anteriorly, an inner and an outer which encloses a deep vertical concavity. The inner exhibits the suture with the pterygoid bone, the outer with the zygomatic. The superior border of the quadrate within the sqaumosal is massive and not inflated. Its surface is thickest where the usual articulation with the opisthotic exists. The posterior horizontal is short and deep. The transverse part of the bone which supports inferiorly the exterior part of the condyle is thin, and disappears above the antero-posterior portion. From its middle upwards it supports the *zygomatic*. The latter has no great extent anteriorly to its malar suture, and its inferior margin arches high above the line of the condyles of the quadrate.

The *pterygoid bones* are subtriangular in outline, with concave sides, an emarginate base, and a very obliquely truncate apex, which articulates low down on the quadrate bone. Both margins are thickened and rounded, the superior as boundary of the foramen ovale. The posterior margin of the plate-like columella overlaps it on the inner side, deeply notching it; on the outer side, the suture is zigzag and transverse. The superior part of the bone is produced like a flat rod, and at its end exhibits a squamosal suture for union with what is in the snapper a postero-inferior rod-like prolongation of the columella. No such process of the columella appears to exist in this species. The *columellar plate* is half as large as the pterygoid, and exhibits the oblique suture in front for the descending lamina of the parietal.

The *postfrontal* bone of the left side is preserved entire, and the inferior portion of that of the right. The inferior margin for the malar is the longest and is straight. The orbit is excavated in part from its anterior margin, while the supero-posterior is a continuous curve. The inferior suture is a groove, whose inner bounding wall is convex, but rises past the straight outer to an inner ridge, which probably approaches the eclopterygoid region. A large sutural face for the zygomatic exists at the tower posterior angle, and an elongate one above for the parietal. The inner face is concave, indicating a large temporal fossa as in *Sphargis* and *Chelone*.

Two bones of opposite sides of the cranium are either those portions of the pterygoids which bound the temporal fossa below in front, or those portions of the maxillary bounding the palatine foramen. As the free margin is much thickened they are probably the former. Their inner or thinner lamina is marked for squamosal suture with other bones, perhaps columella and palatine.

Measurements of Cranium.	M.
Depth premaxillary suture of maxillary	0.06
Length from do. suture to inner nares	.068

	M.
Depth maxillary below orbit	.035
" dentary at symphysis	.078
" notch of do. do	.044
" dentary behind symphysis	.095
" " at coronoid region	.085
" ramus at front of cotylus	.061
Length pterygoid fossa of do	.06
" cotylus do	.07
" postfrontal on inferior suture	.195
Depth " at boundary of orbit	.136
Thickness " lower suture	.019
Length from orbit (oblique)	.115
Length right quadrate	.140
Width (antero-posterior)	.110
" of condyle	.064
Length right pterygoid superiorly	.155
Depth do. at inner columellar angle	.100
Length (oblique) of columella	.085

Restoration. Better materials exist for the restoration of this species than is usual in the case of most extinct *Testudinata*. The cranium was .50 M., or $24\frac{3}{8}$ inches in length. If the neck and carapace were related to it, as in the genus *Chelone*, the total would be as follows:

	Inches.
Cranium	$24\frac{3}{8}$
Neck and carapace	$138\frac{3}{8}$
Total 12.83 feet	$154\frac{7}{8}$

an extent not far from the expanse of the flippers above given, viz., 11.30 feet. The shortness of the cervical vertebræ indicate that the proportions of the neck were not dissimilar to those of the existing marine genera. The flippers were probably similar to the same; of the hind limbs nothing can now be stated. The shortness of most of the ribs considered in connection with the length of the carapace, is remarkable. Thus the longest rib measures .51 M. or 16 inches; width of lateral marginal beyond apex of rib 2.25 inches; width of vertebra 3 inches, which is, however, covered by the expansion of the rib, included in this case in the length 16 inches. Total width of carapace at middle, $36\frac{1}{2}$ inches. Length of carapace 118 inches; or wide 3 feet $\frac{1}{2}$ inch; length 9 feet 10 inches. This outline, three times as long as wide, is justified in measure by the size, especially the lengths, of the marginals, which if placed end to end, would measure on one side of eleven pieces, if each were as long as the median, 8.5 inches $\times$ 11 = 7.8 feet. Some of the posterior marginals are shorter than 8.5 inches, while some of the anterior appear to be longer. The length 8.5 may then be taken as an average. But they formed the circumference of an open arc, so the axial length of the carapace should be placed at a lower figure than the above. This proposition may be offsetted by the fact that the marginals were not united to each other and

exhibit no indications of contact. The length of 7.8 feet, for the carapace is not then too much, and estimating from the size of the head is too little. We can then safely conclude that the carapace of this turtle is more elongate and narrowed than existing forms. Thus in *Chelone mydas* the carapace is six-eighths as wide as long.

It remains to discuss the question of the age of the specimen. It might be objected that the absence of carapace, and the radiate character of the margins of many of the bones indicate that our type specimen is young. To this it may be replied (1), that it is in the (?) sternal bones unlike the young of any known type, when certain of their bodies do at all times exhibit smooth margins as boundaries of the points of exit of the limbs; moreover, it is possible that these plates were dorsal. (2) The superior or inner extension of the marginals exceed that of any known tortoise in the adult condition. (3) The articular bone is ossified. (4) Separate ribs should be discovered among extinct tortoises as an adult character, on theoretical grounds, the more as it exists in one recent genus (*Sphargis*, vide Wagler).

Affinities. In discussing these, one point heretofore left doubtful may be first considered. The large flat elements described as lateral dermal bones; are they ossifications of the dorsal or ventral integument? They were found below all the other bones, and nearly all the ribs laid on them with their heads turned upwards. This rendered it probable that the shields were dorsal, and that the animal was entombed on its back, and a coracoid, which was afterwards found lying immediately on the largest bone (No. 10), crossed in its course parts of two ribs. This could not have been the case had the shields been ventral. An examination of the shields does not reveal any conformity to any known type of Testudinate plastron. The bones radiate in all directions, leaving no margins for fore and hind limbs, or for a median fontanelle, still less for suture with each other.

Should these bones then be regarded as dorsal, they constitute a character not previously noticed in the order, but one whose homologue is seen probably in the dermal shield of bony tesselated plates seen in *Sphargis*. The other points of affinity to *Sphargis* are the distinct ribs; the thin laminiform jaws with cutting edges; the quadrate bone with such a strong anterior concavity; the elevated position of the zygomatic bone; the form of the humerus. Points of special resemblance to *Chelone* are: the short posterior superior portion of the quadrate; the entire edge of the maxillary bone; the deep dentary. The points in which it differs from both, are numerous. They are: the dorsal shields, the marginals, the notched symphysis, etc.; the shortened articular end of scapula; the elongate form of the carapace, etc.

The constant separation of the ribs, and the short vertebræ, are characters which are more like those possessed by other reptiles, than those characteristic of *Testudinata*. The presence of dermal dorsal bones is of the same kind. The genus *Protostega* then belongs near the *Sphargididæ* in the suborder *Athecæ*, and is in some points to be approximated to the *Chelonididæ*.

Distribution. This fossil was found near Ft. Wallace, W. Kansas. It was entirely recovered by excavating. The edges of one of the large bony shields were seen projecting from a bluff near Butte Creek, and was followed into the chalk rock with pick-axe and shovel with the result already indicated. The large bones were exposed in an entire condition, but were much fractured in the attempt to lift them from their bed. Though carefully packed, the transport of 1500 miles still further injured them, and the portions described were reconstructed of over 800 pieces by myself. One of the bony plates was broken into 108 pieces, the ribs into 183, the marginals into 146, etc.

This species may be called *Protostega gigas*, Cope.* A second species appears to have existed during the Cretaceous period, as indicated by a humerus from near Columbus, Miss., sent by Dr. Spillman to the Academy of Natural Sciences. With it were received bones of the Mosasauroid *Platecarpus tympaniticus*, and Dr. Leidy, who described them,† regarded all as belonging to one animal. On this basis he expressed the opinion that the fore limbs of the *Pythonomorpha* were natatory. That this view was correct I proved by study of the skeleton of *Clidastes propython*, and it now appears that the fore limbs of the latter were the first ever described.

The humerus of the Mississippi *Protostega* (see Leidy, l. c., Pl. viii., Fig. 1–2) is more elongate than that of the *P. gigas*, and is less contracted medially. The (great trochanter or) deltoid crest is longer and stouter, and the process answering to the little trochanter is more prominent, rounded, and proximal in position. It indicates a rather smaller animal than the Kansas specimen, and may be named *Platecarpus tuberosus*.

A third species is represented by a humerus found in the cretaceous green-sand of New Jersey. It was a huge animal, exceeding not only the species just described, but even the Indian *Colossochelys atlas*. usually regarded as the largest of the order. It was regarded by Leidy as pertaining "to the great *Mosasaurus*," but Agassiz regarded it as Chelonian in affinities, naming it *Atlantochelys mortonii*.‡ Its great trochanter is very prominent, as in *P. tuberosus*, but the lesser one is smaller and nearer the condyle or head. The shaft is still more slender and not flattened, but subcylindric. It may be called *Protostega neptunia*. It is figured by Leidy, l. c. Pl. viii. fig. 3, 4. In this connection may be recalled the vertebræ of a gigantic animal from the New Jersey Cretaceous, described by the writer as belonging to an extinct species and genus under the name of *Pneumatarthrus peloreus*. It is quite likely that these belonged to a turtle still larger than the *Protostega neptunia*. (See Proceed. Amer. Philos. Soc., 1870, p. 446.)

*Proceed. Amer. Philos. Soc. 1871, p. 173.

† Cretaceous Reptiles of North America, p. 42. Smithson. Contrib. 1864.

‡ This name was unaccompanied with the necessary description, and is hence useless to science.

Stated Meeting, March 15, 1872.

Present, 12 members.

Vice-President, Mr. FRALEY, in the Chair.

Prof. Edwin J. Houston, a newly elected member was presented to the presiding officer and took his seat.

Photographs for the album were received from Mr. George Davidson, U. S. Coast Survey, and from Prof. O. C. Marsh, of New Haven.

A letter requesting exchange of publication was received from Prof. C. F. Chandler, Editor of the American Chemist, dated School of Mines of Columbia College, corner of 49th St. and Fourth Avenue, New York, March 12, 1872. On motion, the American Chemist was ordered to be placed on the list of correspondents, to receive the Proceedings.

A circular letter was received from the Royal Academy of Sciences of Belgium, inviting the Society to assist at its Centennial Anniversary, May 28th and 29th next ensuing.

Letters of envoy were received from the P. O. Society at Königsberg, dated July 10, 1871, and from the Central Bureau of Statistics at Stockholm, dated Nov. 4, 1871.

Letters of acknowledgment were received from the Central Bureau of Statistics at Stockholm (81 to 85). Le Bureau des Longitudes, at Paris, dated Nov. 19, 1871 (82, 83); Feb. 14, 1872 (86). The Smithsonian Institute, Feb. 28, 1872 (87), and the Congressional Library, March 5, 1872 (XIV iii.).

Donations for the Library were received from the C. B. of Statistics of Sweden, the Society at Königsberg, the Royal Academy at Berlin, the K. K. Geological Institute and Anthropological Society at Vienna, the Royal Library at Munich, the Montsouris Observatory and Bureau des Logitudes at Paris, the Revue Politique, the Royal Geological Society of Cornwall, the Museum of Comparative Zoology at Cambridge, Mass.; the American Journal of Science, the New York Lyceum of Natural History, the Albany Institute, Prof. Chandler, the New Jersey Historical Society, the American Pharmaceutical Society, the Medical News and

Library, the Franklin Institute, the Penn Monthly, the Librarian of Congress, the Chief of U. S. Engineers, Senator Charles Sumner, and Prof. F. V. Hayden.

The death of Christian Olrik, of Denmark, a member of the Society, was announced by the Secretary.

The committee to which was referred the paper of Prof. Stevenson, on West Virginia Coal Measures, reported in favor of its publication in the Transactions, which on motion was so ordered.

A communication entitled, On some remarkable relations between the mean motions of Jupiter, Saturn, Uranus, and Neptune, received by letter from Prof. Daniel Kirkwood, dated Bloomington, Monroe County, Ind., March 11, 1872, was read by the Secretary.

On some Remarkable Relations between the Mean Motions of Jupiter, Saturn, Uranus, and Neptune.

By Prof. Daniel Kirkwood.

(*Read before the American Philosophical Society, March 15th,* 1872.)

It was noticed by the writer several years since, that 85 periods of Jupiter are nearly equal to 12 of Uranus,* and that 149 periods of Uranus are approximately equal to 76 of Neptune. If, therefore, n^{v}, n^{vi}, n^{vii} and n^{viii} denote the respective mean motions of Jupiter, Saturn, Uranus, and Neptune, these relations are expressed as follows:

$$12n^{v} - 85^{vii} = 76^{vii} - 149^{viii}, \text{ nearly};$$

or, $$12n^{v} - 161n^{vii} + 149n^{viii} = -\gamma \quad . \quad . \quad . \quad . \quad (1).$$

With Newcomb's value of n^{viii} and the values of n^{v} and n^{vii} adopted in the *American Ephemeris*, we find $\gamma = 390''$. The equation,

$$32n^{vi} - 153n^{vii} + 121n^{viii} = -\gamma \quad . \quad . \quad . \quad (2),$$

was obtained by a process somewhat similar. Subtracting (2) from (1), and dividing by 4, we have

$$3n^{v} - 8n^{vi} - 2n^{vii} + 7n^{viii} = 0, \quad . \quad . \quad . \quad . \quad (3).†$$

This equation, like that which exists between the mean motions of Jupiter's first three satellites, is doubtless exact. The mean motion of Neptune is less accurately known than those of the old planets. If we assume, then, that the received values of n^{v}, n^{vi}, n^{vii}, are correct,

* Runkle's Mathematical Monthly, January, 1860.

† Equation (3), without any account of its discovery, was given in Silliman's Journal, March, 1872.

the value of n_{viii}, found by equation (3), is 7863″.983, differing from Newcomb's value (7864″.935) by less than 1″.

The corresponding relations between the *mean longitudes* of the four outer planets are sufficiently obvious. Thus,

$$3l^{v} - 8l^{vi} - 2l^{vii} + 7l^{viii} = \chi = \text{a constant} \quad . \quad . \quad . \quad (4).$$

With a slight correction of the elements, it will probably be found that $\chi = 135^{\circ}$.

Again: the equation,

$$17n^{vi} - 228n^{vii} + 211n^{viii} = 0, \quad . \quad . \quad . \quad . \quad (5).$$

found in the same manner as (1), is believed to be exact. Combining (3) and (5), we obtain

$$68n^{vi} - 325n^{vii} + 257n^{viii} = 0, \quad . \quad . \quad . \quad (6),$$
$$257n^{v} - 844n^{vi} + 587n^{vii} = 0, \quad . \quad . \quad . \quad (7),$$
$$325n^{v} - 912n^{vi} + 587n^{viii} = 0, \quad . \quad . \quad . \quad (6).$$

These equations indicate that in a cycle of about 11657.2969 Julian years, the planets Jupiter, Saturn, Uranus, and Neptune return to the same relative mean longitudes, The equations are all satisfied by the following values. The received values are given for the convenience of comparison. In column first $\delta'' = \frac{1296000''}{11657.2969}$.

THEORETICAL VALUES.		RECEIVED VALUES.	DIFFERENCES.
n^{v}	= 109256″.719	109256″.719	0″.000
$n^{vi} = n^{v} - 587\delta'' =$	43996.971	43996.127	+0″.844
$n^{vii} = n^{v} - 844\delta'' =$	15424.986	15424.509	+0″.477
$n^{viii} = n^{v} - 912\delta'' =$	7865.083	7864.935	+0″.148

The received value of Jupiter's mean motion is here assumed to be correct. Any change would produce a corresponding variation in the remaining values. A revision of the theory of the orbits will, of course, result in some slight modifications. I believe, however, that the relations expressed by the preceding equations will be found strictly exact. If so, it must follow that *no three of the four outer planets can ever be in conjunction at the same time.*

BLOOMINGTON, IND., *February*, 1872.

Stated Meeting, April 5, 1872.

Present, 21 members.

Vice-President, Prof. JOHN C. CRESSON, in the Chair.

Letters of acknowledgment were received from the Royal Academy, Lisbon, Feb. 16, 1872 (XIII. iii. 81, 82); The Royal Institution, London, Feb., 1872 (XIV. iii. 87—XIV. ii. wanted); The Anthropological Institute of Great Britain and Ireland, London, March 21, 1872 (XIV. iii. 87); and the New York Lyceum, N. H., March 25, 1872 (XIV. iii.).

Letters of envoy were received from the U. S. Naval Observatory, Washington, March 25, 1872, and the New Jersey Historical Society, Newark, March 30, 1872.

Donations for the Library were received from the Russian Geographical Society, the R. Prussian Academy, the R. Belgian Academy, the Paris Geographical Society and Revue Politique, the Royal Astronomical Society, Meteorological Office, and Editors of Nature; the Argentine Astronomical Observatory, American Antiquarian Society, Essex Institute, Boston Old and New, American Journal of Science, American Chemist, Prof. James Hall, New Jersey Geological Survey, New Jersey Historical Society, Philadelphia Water Department, American Journal of Pharmacy, Gen. Hector Tyndale, the Franklin Institute, U. S. Naval Observatory, and Minnesota Historical Society.

Mr. Sol. W. Roberts, pursuant to appointment, read an obituary notice of the late Mr. Edward Miller.

The death of Mr. Samuel Jackson, on the 4th instant, in Philadelphia, aged 85, was announced by Mr. Fraley.

The death of Dr. Samuel H. Dickson, on the 31st ult., in Philadelphia, aged 72, was announced by Mr. Fraley.

The death of Mr. Elwood Morris, on the 2d inst., aged 59, was announced by Mr. Roberts.

The death of Prof. S. F. B. Morse, on the 3d inst., aged 81, was announced by Prof. Cresson.

Mr. T. B. Brooks, State Geologist of Michigan, read a paper on "Magnetism of the Rocks of the Marquette Re-

gion," near Lake Superior, which was referred to a Committee, consisting of Prof. Lesley, Dr. Genth, and Mr. Lyman.

Mr. Eli K. Price presented for record a notice of the Aurora of February 4th.

Mr. Chase communicated a note of new relations between the distances of the Moon from the Earth, and those of Jupiter and the Earth from the Sun.

Pending nominations, Nos. 689, 690, 691, 692, were read,

And the meeting was adjourned.

Stated Meeting, April 19th, 1872.

Present, 25 members.

Vice-President, Mr. Fraley, in the Chair.

A letter, acknowledging receipt of Diploma, was received from Major R. S. Williamson, U. S. C. S., San Francisco, April 10th, 1872.

A letter, acknowledging the receipt of Transactions XIV. iii., and Proceedings No. 87, was received from the London Society of Antiquaries, Somerset House, March 28th, 1872.

Donations for the Library were received from Dr. Carl Neuman, of Leipzig; SS. Mantegazza and Finzi, of Florence (Archivis Anthro. e Eth.); M. Delesse, of Paris; the Revue Politique, London Nature, R. Geological Society of Ireland, Rev. Samuel Houghton, the Boston Society of Natural History, American Numismatic and Archæological Society, Prof. O. C. Marsh, of New Haven; American Journal of the Medical Sciences, News and Library, Penn Monthly, American Iron and Steel Association, Dr. Elder, Mr. Eli K. Price, Mr. George Davidson, the Coast Survey, Smithsonian Institution, and University of Virginia.

Prof. J. F. Fisher mentioned the death of the distinguished Genevan, M. Pictét de la Rive.

The Committee to which was referred the map and paper on a Coal District in Southern Virginia, reported recom-

mending the publication of the same in the Transactions; which was so ordered.

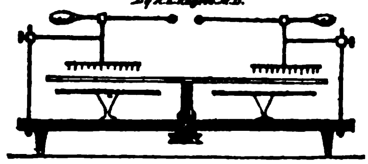
The Committee to which was referred the paper on the Magnetism of Rocks, &c., by Major T. B. Brooks, reported that, since the Legislature of Michigan had recently made an appropriation for the publication of the whole Report of the Survey of Major Brooks' District, they recommend that the Secretaries be requested to prepare an abstract notice of the paper for the Proceedings. The report was concurred in.

Prof. Chase, according to notice given, gave an explanation of his method of estimating the Sun's mass and distance by the energy of flames, with diagrams and tables.

Prof. Persifor Frazer, Jr., communicated the results of his spectroscopic observation of the late Aurora.

Dr. R. E. Rogers exhibited the capacities of a fine Holtz Electrical Machine, and described his proposed modification of its form for purposes of instruction.

Modified form of Holtz Electrical Machine.
By R. E. Rogers M.D.



The prime plate is replaced by horizontal plates, laid upon wine glasses, or upon removable rubber standards. The rotating plate is made to rotate horizontally over them, its axis passing vertically downward through the table, the driving wheel being underneath. Two standards carry the combs, etc., and can be swung round out of the way. Every part of the machine can be removed in a charged state, to be tested and compared with its condition before removal.

The Secretary exhibited a water-color picture of a geological sectional model of Morrison's Cove, in Middle Pennsylvania, painted by Mr. J. W. Harden, C. and M. Engineer, of Philadelphia, and invited attention to the highly artistic style and beauty of the work.

Pending nominations, Nos. 689 to 692 were read, spoken to, and balloted for. New nominations, Nos. 693 and 694, were read. There being no further business, the ballot-boxes

were scrutinized by the presiding officer, and the following gentlemen declared duly elected Members of the Society:

M. Jean Baptiste Léon Say, Prefect of the Seine, Paris.

Mr. Lorin Blodget, of Philadelphia.

Dr. D. Hayes Agnew, of Philadelphia.

Mr. Adolph E. Borie, of Philadelphia.

And the meeting was adjourned.

Stated Meeting, May 3d, 1872.

Present, 18 members.

Vice-President, Prof. CRESSON, in the Chair.

A letter accepting membership was received from Dr. D. Hayes Agnew, dated 1611 Chestnut Street, Philadelphia, April 22, 1872.

A Circular Letter, signed by the Mayor of Strasburg and others, requesting donations to the Municipal Library of that city, destroyed August 24, 1870, was read.

On motion, the request of Prof. Stevenson, to print a note to his Memoirs in the Transactions, was granted.

Donations to the Library were announced from the Royal Academies at Berlin and Brussels, the Geographical Society and Political Review of Paris, London Nature, the Canadian Naturalist, Old and New, Silliman's Journal, American Chemist, Prof. Mayer, the Franklin Institute, College of Physicians, Pennsylvania Historical Society, and Dr. Hayden.

The death of John P. Brown, a member of the Society, at Constantinople, on the 28th ult., was announced by the Secretary.

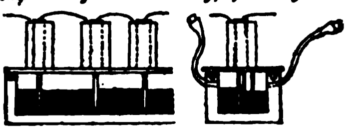
The death of Dr. W. W. Gerhard, a member of the Society, at his residence, 1206 Spruce Street, Philadelphia, April 28th, aged 63, was announced by the Secretary.

Dr. Rogers explained to the members present his improved

Galvanic Battery; and also an improved method of analyzing irons and steels for their contained carbon, by the use of bichromate of potassium:

The wood-cut represents a trough, on which stands the battery of cups. A pair of tubes descend from each cup, through the lid of trough, into the liquids. The trough is divided lengthwise by a diaphragm. The tubes of each pair descend one on each side of the diaphragm. The lid of the trough is made air-tight, by the following arrangement: A groove is sunk in the upper edge of of the four walls of the trough, and a bead to fit the groove runs round the under side of the lid near the edge. The groove being half filled with mercury, the joint is kept air-tight by the weight of the lid and battery. An India-rubber pipe enters the trough, and the breath (or a bellows) is sufficient to cause the liquids to ascend into the cups of the battery during work. After work, the cork is withdrawn from the mouthpiece of the India-rubber tube, and the liquors fall back into the trough. The lid and battery can then be removed and washed.

Improved Galvanic Battery, by R. E. Rogers MD.



Mr. Lesley described the faulted structure of the district around Embreeville, in East Tennessee; and exhibited a suite of European iron ores, owned by Mr. Thomas Graham, and another of the ores of North Carolina.

Prof. Cope described the sightless fauna of the Mammoth, Wyandotte, and other Caves.

Pending nominations, Nos. 693, 694, 695, were read,

And the meeting was adjourned.

Stated Meeting, May 17th, 1872.

Present, 13 members.

Vice-President, Mr. Fraley, in the Chair.

A letter accepting membership was received from Professor Guillaume Lambert, dated Bruxelles, Rue Traversière, No. 78, April 30, 1872.

A letter acknowledging receipt of Transactions, XIV., i. ii., and Proceedings, 78–85, was received from Professor Paolo Volpicelli, dated del Campidoglio, Roma, Reale Acc. d. Lincei, December 12, 1871.

Donations for the Library were received from Gehe & Co., of Dresden, the Revüe Politique, London Nature, the R. Astronomical Society, Cambridge Museum of Comparative Zoölogy, Boston Society of Natural Sciences, Buffalo Young Men's Association, Dr. Geo. B. Wood, Mr. Sol. W. Roberts, the Medical News, Penn Monthly, Petroleum Monthly, Wilmington Institute, and U. S. Corps of Engineers.

Professor Chase exhibited an annual Auroral Curve and explained its relations to the periodic maxima and minima of meteoric displays, &c.

Professor Chase exhibited a drawing to illustrate the capacity of Mr. Holman's pen to draw continuous lines of any length and thickness.

Professor Chase then gave in tabular form, various recently calculated planetary relationships.

Dr. Rodgers described his manner of obtaining an unlimited supply of electricity by the steam jet from a high-pressure boiler, not insulated, and in all weathers.

This gave rise to a discussion of electrical phenomena during volcanic eruptions and earthquakes.

Pending nominations, Nos. 693 to 695, and new nomination, No. 696, were read,

And the meeting adjourned.

Stated Meeting, June 21, 1872.

Present, 8 members.

Vice-President, Mr. FRALEY, in the Chair.

Photographs for the Album were received from Dr. Ed. Jarvis of Dorchester, Mass., Dr. Elisha J. Lewis of Philadelphia, and Judge W. H. Lowrie, of Meadville, Pa.

A letter accepting membership was received from M. Léon Say, dated Paris, 10th May, 1872.

Letters, acknowledging receipt of publications, were received from the Hungarian Academy, May 4, 1872 (XIII.,

3; XIV., 1, 2: 81-86); Herr G. Von Frauenféld, Vienna, 12, 1871 (82); Astronomical Society, Leipsic, February 20, 1872 (86); Royal Library, Berlin, March 1, 1872 (86); Royal Society, Göttingen, January 10, 1872 (XIV., 1, 2: 83, 84, 85); Royal Academy, Lisbon, October 5, 1871 (XIV., 1: 83, 84, 85); and the Smithsonian Institution, Washington, May 4, 1872 (XIV., 3).

Letters of envoy were received from the R. Society, Göttingen, January 10, 1872; the Central Statistical Bureau, Stockholm, April 8, 1872; Royal Saxon Society, Leipsic, October 31, 1871; Dr. Edward Jarvis, Dorchester, Mass., June 12, 1872; and the U. S. War Department, Signal Service Officer Albert J. Meyer, May 31, 1872.

Donations for the Library were received from Dr. Ed. Jarvis; also, from the Swedish Central Statistical Bureau, Russian Academy, Dorpat Observatory, Moscow Society of Naturalists, Austrian Geological Institute, Prussian Academy, Saxon Society, Lausitz Magazine, Göttingen Society, Zoological Garden at Frankfort, Vaudoise Society, Geological Committee of Italy, Montsouris Observatory, French Geographical Society, M. M. Delesse & Laparent, National Society of Antiquarians (Paris), Anthopological Society, Society of Acclimatation, Bureau des Ponts, &c., Revue Politique, Bordeaux Society of Sciences, London Royal Society, Royal Institution, Astronomical Society, Meteorological Committee, Chemical Society, Entomological Society, Cobden Club, Sir Henry Holland, Nature, Royal Society Dublin, Rev. L. Haughton, Essex Institute, Massachusetts State Library, Boston Public Library, Old and New, Silliman's Journal, Professor O. C. Marsh, American Chemist, Professor B. C. E. Anthon, Professor James Hall, Franklin Institute, College of Pharmacy, Medical News, Penn Monthly, Isaac Lea, J. C. Cresson, Lorin Blodget, the Secretary of the Interior, Census Bureau, Signal Service Bureau, and the California Academy of Sciences.

Dr. Emerson desired to have placed on record the destruction of Norway Fir, Arbor Vitæ, and Osage Orange, as far

south as the latitude of Philadelphia, either by cold or long drought, or both.

Professor Trego gave an account of the destruction in Germantown.

Mr. Blodgett added his notes of the Meteorology of March 5th, 6th and 7th, during which a cold, dry gale prevailed, to which he ascribed the loss of these plants. Fruit trees, when their time for flowering arrived, showed an inability to blossom for seveial weeks, as if paralyzed; the dryness of the gale of March seemed to have exhausted the sap. Many of the White Pines of the Alleghany Mountains were also killed.

Pending nominations, Nos. 693 to 696, and new nomination, 697, were read,

And the meeting was adjourned.

Note on a fine Upthrow Fault at Embreeville Furnace in East Tennessee.

By J. P. Lesley.

(*Read before the American Philosophical Society, May 3d,* 1872.

In a late visit to the works at Embreeville, on the Nolichuckee River, in Washington County, East Tennessee, I made a compass and barometer survey of the river valley and Bompas Cove, connecting the Furnace with its flux quarry and ore banks, tram road, washing ground, slack-water channel, etc., which will be found delineated on the accompanying map, drawn on a scale of 4,000 feet to the inch, with contour lines of 20 feet elevation to express the topography.*

* The accompanying map was hastily sketched for reproduction by Mr. Bien's photo-lithographic process. It merely shows the character of the topography of a portion of the property. But it is accurate so far as regards the course of the river, the hills which enclose it, the sand-rock outcrops, the north end of Bompas Cove, the grade contours of the railway and ravines, the elevation of the mines, &c. All the rest, including the heights and contours of the mountains, must be considered merely approximations to the truth. The contour lines represent elevations of 20 feet successively above tide-water, commencing at about 2,000 feet. The section below the map represents the geology along the river, above and below the Furnace. The scale was originally 1,000 feet to the inch. It was photographed down to 3,000 to make a plate. That plate was lost in the fire which rendered a second edition of this Number of the Proceedings necessary. An original copy from the first plate was then photographed down to 4,000 *feet to the inch*, to make the present plate.

Scale 4000 ft. to the inch.

The Furnace stands in the gap which the Nolichuckee makes through the last range of mountains on its way out from the North Carolina Highlands to the Great Limestone Valley of East Tennessee. A double rib of massive sandrock here forms a natural dam and mill-race, affording unlimited water-power, protected by projecting fragments of the sandrock outcrop from the most violent freshets. It is a scene of rare beauty, and a remarkably favorable location for any kind of industry requiring power. A broad terrace affords ample room for several furnaces and their dependent outworks, a village, mills of different kinds, and, in fact, for a Rolling Mill of the first class.

At present there stands here one Furnace, of small size, making 6¼ (six and a quarter) tons of metal per day at the time of my visit, a saw mill, an ochre mill, a village, store, church, and Superintendent's mansion.

A rope-ferry communicates with the State Road on the opposite shore. Jonesborough—the capital of the county, and oldest settlement in the State, on the East Tennessee, Virginia and Georgia Railroad, 32 miles from Bristol, 98 from Knoxville, 210 from Chattanooga, 236 from Lynchburg, 440 from Norfolk, and 391 from Richmond—is eight (8) miles distant from the furnace by this State Road. A railway could be made without difficulty over these eight miles, along smooth vales of limestone land, which head up towards Jonesborough. My barometer along the State Road gave me 200, 300 and 340 feet as the summit elevations above the river at the ferry. The intervals were from 50 to 100 feet lower. Railroad grade at Jonesborough was something under 200 feet above the ferry. A line might be located with maximum gradients of 50 feet to the mile, and with little or no cutting and filling, except for the first half mile below the furnace in the gap. Ten or twelve thousand dollars a mile ought to be quite sufficient to build the road. The bridge at the Furnace would be 200 feet long, but would need no piers, nor abutments: these being provided by nature in the shape of colossal sandrock outcrops rising fifty feet above the river bed.

The metal made at the Furnace goes chiefly to the Tredegar Works at Richmond, 400 miles from the Furnace, costing $3.25 a ton to haul to Jonesborough, in the present state of the roads. In dry seasons, the limestone roads become smooth and hard.

Up the river to the south and east, locked in among hills of irregular trend, steep slopes, and bluffs of crumbling rock, from 600 to 1,000 feet high, lie two limestones coves: Bompas Cove, drained by Bompas Creek, flowing north into the river at the Furnace washing ground, two miles from the works; and Greasy Cove, drained by streams flowing southwestward to the river, and about six miles from the works.

Bompas Cove is an oval valley three or four miles long, by one and a-half wide at its widest part, surrounded by mountains about a thousand feet high, on the inner slopes of which rest terraces or hill-spurs of decomposed limestone (Lower Silurian) holding masses of brown hematite iron ore of two varieties; the lower series (and outer, or closer up to the

mountain wall) being silicious and cold-short, and the upper series being argillaceous and red-short. The cove is nearly encircled by the cold-short deposits, which have been opened in a number of places, and a good deal mined, towards the head of the cove, for an old furnace further south. The red-short hematites are extensively spread out more in the middle of the cove, where they are capped by lead-bearing members of the Limestone formation.

There are a few fertile farms in the cove; but an uninterrupted forest covers all the mountain country around it, most of which is included within the limits of the estate.

Greasy Cove is a large and nearly level limestone plain, more than twenty miles long by five miles wide, similarly surrounded by shale and sandstone hills nearly 1,000 feet high and backed by the State Line Range of the Unaka (Sub Silurian) Mountains more than twice as high. The Nolichuckee enters this cove from the mountain country to the south, and leaves it by a gorge, the south wall of which is a towering cliff of sandstone 500 or 600 feet in vertical height, called the Devil's Looking Glass. It flows thence three miles straight north-northwest towards the mouth of Bompas Cove, where it makes an ox-bow, and then flows north to the Furnace, as shown in the map.

This interval of three miles is made through forest-covered hills. Paddy's Creek and Broad Shoals Creek form narrow forest-covered valleys, entering the river valley from the southwest. Another stream of equal size forms a similar valley on the northeast. All this is good coaling ground for iron-works; and depots of charcoal can be established at different points on the two banks of the river, down which the fuel can be safely and cheaply boated. Two large charcoal furnaces at Embreeville could be erected in view of a constant supply of charcoal by the organization of an extensive system of coaling depots up the river. A forest surrounds the head of Greasy Cove and passes in an unbroken belt across all the hill country back of the river bottoms, over to the *Dry Creek Valley*, and Buffalo or Cherokee Mountain, north-northeast and east of the Furnace. This is on the east side of the river. On the west side, as I have said, many square miles of forest-covered hill country surrounds Bompas Cove.

This forest consists of white oak, spruce pine, poplar, hickory, etc., most of it in its original condition. Some tracts have been coaled off once, others twice. After fifteen or twenty years they are ready for coaling again. I saw a few trees two feet in diameter; but the forest trees are lighter than I am accustomed to see in Pennsylvania. They will probably yield, on an average, 40 or 50 cords to the acre, while some ravines will go up to 100.

The charcoal used at the Furnace is good and strong, but by the hauling over steep roads, and several handlings, the waste amounts to 25 or 30 per cent. Most of this could be saved under a more extensive and complete organization of this part of the business, and by the use of

large baskets on trucks. The coal floors are near enough the Furnace to allow the carts to go to it twice a day; some, however, can be reached but once a day. The dependence of extensive works must be on a river navigation and coaling depots above, as has already been said.

One hundred and ten bushels of charcoal go to the ton of iron at this furnace, making, say, six tons. An enlarged stack could easily make ten or twelve. The Shelby Furnace in Alabama, sixty feet high, is making at the present moment, with charcoal, sixteen (16) tons, by information I have indirectly from the keeper, although it is reported she has made twenty. The report is incorrect; she has never exceeded sixteen. But this shows what *can* be done with charcoal and brown hematite ore. In smelting rich fusible lump ore, one ton of metal requires from *one-third* to *one and a-quarter* tons of hard charcoal, or from *one and a-half* to *three* tons of soft charcoal.

Coke, however, is the future dependence of Embreeville Works on an extensive scale. The Cumberland Mountain, west of Knoxville, (Coal Creek, Cove Creek, etc.,) has numerous workable beds of good bituminous coking coals. The Knoxville and Kentucky Railroad is already carrying these coals from the mines to the factories and ironworks of Knoxville and other towns along the East Tennessee Railroad, including Jonesborough. Contracts can be made for the delivery of any amount of Cumberland Mountain (Waldron Ridge) coal at Jonesborough, for $3.25 to $3.50 per ton. If the eight mile branch to Embreeville were built, costing with bridge and rolling stock, say $150,000, the coal could be landed at the Furnace at a cost of something under $4, and there coked; or, which would be better, coking establishments could be organized in the Cumberland Mountains, along Cove Creek, and the coke be deposited at Embreeville for about $4.50, owing to the fact that—1. One-half the weight of the car-load would be saved by carrying it in the form of coke; 2. The waste in dust would be saved; and, 3. The slake waste at the mines would be coked with the lump.

Now, 6¼ cents a bushel is paid at the Furnace for charcoal, or, $6\frac{1}{4} \times 110 = \$6.87\frac{1}{2}$, to make a ton of metal.

Coke furnaces require from 1.1 to 2.3 tons of coke to make 1 ton of iron, according to their size, shape, and especially the quality of ores employed. For brown hematites it would not be safe to assume less than 1½, and it might go up to 1¾ tons of coke to one of metal. If coke could be got at Embreeville for $4.50, the coke for 1 ton of iron would still cost $6.75, as against $6.87½ for charcoal.

But while a charcoal furnace is producing 45 tons of metal a week, a coke furnace with hot blast is producing from 150 to 200 tons a week.

It would be unwise to erect more than two first-class charcoal furnaces at a point like Embreeville, in view of the extensive and complicated system of coaling and boating required. These would make 10 tons a day each, or 140 tons of metal per week. Whereas four coke furnaces might

be put in blast safely, making together (with one always out for repair, etc.), say 3×150—450 tons of metal per week; or even 600 or more.

On the other hand, no profit could be made on coke bought at the mines; and no profit on coal, but only on the coking of the coal at the Furnace, by supplying store goods for wages; whereas, the $6\frac{1}{4}$ cents per bushel paid for the charcoal is paid in stores, and a large saving accomplished.

The same is true of other labor, at the Furnace and at the mines; but this would not be changed by the substitution of coke for charcoal.

Another consideration, and one of importance, is the change in the quality of metal produced. So long as the lowest beds of the Cumberland Mountain system are mined, the coal will be second rate, and even if the best precautions are taken, the coke will not be so good a fuel as charcoal. Quality of metal would have to be sacrificed to some extent for the sake of quantity. The metal made at Embreeville could hardly be better than it is; exceedingly strong in the pig and much esteemed for car-wheel use. The price of such iron must always be high, whatever be the state of the seaboard and foreign markets, because of the limited amount of it made, and always to be made. Much, if not most, of the Tennessee iron must always be cold-short on account of the wide distribution of cold-short ores through the country.

The Brown Hematite, or limonite, deposits of Bompas Cove exactly resemble those of Morrison's Cove, Nittany Valley, Kishicoquilis, and other Lower Silurian limestone valleys of Pennsylvania and Virginia; and those of the long line of the north flank of the South Mountain (Blue Ridge, Smoky Mountain range) from the Hudson River to Alabama. They are in fact situated geologically just like the Allentown, Carlisle, and Chambersburg deposits.

These ores are irregular masses of ochreous clays and loose sands, full of shot and balls and pipes of the hydrated sesquioxide of iron; with coatings of the black oxide of manganese, and traces of the original sulphide of iron, sulphide of lead, and sulphide of zinc, held by the limestone strata before these were dissolved and made cavernous by the drainage waters which have packed the clay sand ore into all the holes and crevices, caves and water-courses thus made.

The general dip of the limestone beds in Bompas is about 10° north-northeast, against a fault which crosses the mouth of the cove and seems to run in a line about N. 15° W., S. 15° E. All the rocks to the east of this line—the rocks in which the river flows—are of an older age, and dip 60° S. 40° E., in very straight bold outcrops, as represented on the map and in the section accompanying it.

This gentle dip of the limestone has exposed several square miles of the ferruginous lower limestone to decomposition; and the quantity of ore is correspondingly great.

The limestone has been cross-cleft; its cleavage planes dipping 45°, more or less. The dissolution has followed these cleavage planes. The

ore-clays are packed in descending cavities sloping at that angle. The massive ore seems to dip 45° therefore, instead of 10°. But as several hundred feet of the nearly horizontal limestone beds has converted itself more or less into ore, the quantity of ore is immense.

The series of ore pits from which the furnace has supplied itself, ranges up the side of a steep hill, beginning at an elevation of about 200 feet above the river (one mile from it), and ending at an elevation of 350 feet. But the ore continues up the hill a hundred feet higher; and descends also below the lowest pit. No system has been observed in mining the ore. Everything has been done hap-hazard and in the most expensive way.

The stripping varies from a foot or two to twenty and thirty feet. The solid ore-ground, consisting of from one-half to four-fifths fine ore, the rest balls, with occasional masses of clay, and occasional masses of solid hard limestone rock (left in its original condition, but with all the edges dissolved round), has been dug into to a depth of ten, fifteen, twenty feet, and more in places, without reaching bottom.

I judged that I saw along the line of pits over the end of the tramway, about one million of tons of ore.

The ore can be followed over the top of the little hill and down its northern side.

Abundant evidence of ore covers the long slope of the hill towards the south for a quarter of a mile.

The same limestone beds take into the isolated hill to the west; and on both sides of this hill near its top are old diggings of the ore, from which the original furnace was supplied for a good many years, and abandoned when that furnace was abandoned, and the new Furnace was erected at Embreeville. The old furnace was situated on Bompas Creek, about half a mile southwest of the present ore mines, and just opposite the lead mine shown upon the map, but inconveniently far from the river.

There must be millions of tons of iron ore in the more central part of the cove, in the low hills composed of the almost horizontal ore-bearing limestone strata, which everywhere show the dissolving action of the ore-collecting waters, and are covered in many places with ore-ground.

The books of the Furnace show that after the ore has been washed and the large lumps roasted to make them more easily broken to pieces, the lowest percentage of ore to pig metal is 49, and the highest 59. The *practical average* of pig iron obtained from the thus prepared ore is fifty-five per cent.*

* Analysis of Brown Hematite ore from Bompas Cove, E. T., made by Prof. Fisher, of U. S. Naval Academy, Annapolis, Md.:

Water and organic matter,	13.15
Phosphoric acid,	.09
Silica,	3.05
Alumina,	1.28
Sesquioxide of manganese,	.27
Sulphur,	.203
Peroxide of iron,	82.27
	100,313

82.27 peroxide of iron equals 57.6 per cent. pure iron.

The weight of the washed ore when dry is one and a half ($1\frac{1}{2}$) tons to the cubic yard. The weight of the lump ore is about $1\frac{1}{4}$ tons to the cubic yard. One car-load of 44,919 cubic inches measurement, *thoroughly dried wash ore,* weighed 3,042 lbs. One cubic yard = 46,656 inches. The lump ore of one car weighed 2,570 lbs.

Very little flux is required by the Furnace, and this is obtained from bold outcrops of blue limestone on the State Road two-thirds of a mile north of the ferry. There is so much lime in the wash ore and in the clay of the ball ore, and so heavy a charge of manganese in the ore deposit that the fluxing of the stock scarcely adds to the expense of its smelting. The cinder is excellent and the waste of iron is evidently small.

Around the inside lining of the tunnel head for about four feet down from the lip of the filling-hole, there forms a coating of concentric layers of a very solid and heavy substance, consisting chiefly of metallic zinc, in alloy with metallic lead and a small quantity of metallic iron.*

The upper and more solid blue and white limestones of Bompas Cove, exposed along the banks of the creek, opposite the old furnace site, contain a good deal of disseminated galena. This is decomposed into carbonate of lead, filling crevices which have been followed down by shafting operations during the late war. The two ores of lead were taken in cars, on a tram road a few hundred yards long, down the creek to a lead mill erected by General Jackson, and there smelted for the use of the Confederate army. The works are now abandoned, and the shafts filled with trash or water.

Brown hematite iron ore deposits have also resulted from the decomposition of the limestone beds over the lead-bearing strata.

Greasy Cove is a district of limestone similar to, but much more extensive than Bompas Cove, and carries the same brown hematite iron ore deposits of probably equal size. The hills overlooking the flat land of this cove on the northwest and within half a mile of the river, are red with ore.

* Analyses, by Persifor Frazer, Jr., Assistant Professor of Chemistry in the University of Pennsylvania, of—

I. *Furnace product* from Embreeville Works, N. C., taken from within four feet of the tunnel head: A hard, brittle, gray solid, with occasional streaks of green, but in powder is grass-green. Specific gravity, 5.6.

Under the magnifying glass it shows minute metallic scales which impart a metallic lustre to the streak when the product is scratched, and yet bear such a small proportion to the whole mass that they are almost indistinguishable with the naked eye.

Silica,	0.28
Iron (calculated as sesquioxide),	4.12
Zinc (oxide),	84.26
Lead (metallic),	6.18
Carbon (as finely divided coal dust determined by loss),	5.16

II. *Lining stone* of Embreeville Furnace, N. C. A yellow sandrock used for the lining of the Embreeville Furnace, and remarkably lasting, was proved to contain:

Silica,	76.99
Alumina and Iron (latter under 2 p. c. Fe_2O_3),	16.12
Magnesia,	2.63
Lime,	1.44
Undermined,	2.83

Considerably more than 50 per cent. of the Silica given above seems to exist as free Silica, or sand.

These details are not only interesting in themselves, but necessary for familiarizing the observer with the scene of a geological action, common enough in our Appalachian region, but rarely exhibiting itself in so bold and telling a way as at Embreeville.

A fault—an upthrow and overshove—a collapsed synclinal at the edge of the thrown-down mass—all this is presented to the eye of the structural geologist, as he stands on the steps of the little Church of Embreeville and looks across the river eastward. Hundreds of feet of limestone outcrop, in part natural cliffs, in part quarry work, demonstrate the problem of Cambrian overlying Silurian—the Quebec Group overriding Trenton Limestone—by drawing it in a grandly visible diagram, a mile long, by 800 feet high.

The solid plates of limestone are bent round in the synclinal without fracture (other than at the great cleavage planes) as though they had been as plastic as wax. A slight anticlinal roll immediately precedes the sudden upturn to a vertical followed by a declining angle in the reversed sense. The exact place of the fault is obscured by a general crush and sheet-covering of the finely broken shale and very thin bedded shaly sandstone layers which make the rest of the mountain mass.

Up through these sandy shales, dividing them into an upper and lower system, rise the bold outcrops of two conglomerate beds, each about 20 feet thick. One of them, forming the crest of the mountain east of the river, descends in a dyke to the water, sinks under the valley, and reappears to face the slopes at the bend at the mouth of Bompas Creek. The other forms a dyke along the foot of the mountain from the Furnace southwest to Bompass Cove. These two coarse sandrocks or finely brecciated conglomerates are shown in the diagram at the foot of the map on page 445, above.

It will be noticed that another set of sandrocks, not at all conglomerate, but semi-crystalline in texture, and (with alternations of softer kinds, and shale bands) at least 100 feet thick, come in above and (being nearly horizontal) cause that hog-back topography seen in the horseshoe bend of the river. It will be noticed also that above these last sandrocks, lies a third or uppermost system of sandy shales. These constitute (with some still higher intercalated massive sandrocks) the bulk of the inwalling river hills (600–800 feet high) all the way up (about 3 miles) to the entrance into Grassy Cove; that is, to the next parallel fault throwing down the Silurians.

It will be evident to those familiar with this characteristic structure of East Tennessee and Southwest Virginia, that the Nolichuckee River exposes a nearly transverse cross-section of a long prism of earth-crust composed of sandy shales, sandrocks and conglomerates, at least 600 feet thick, *elevated* between enclosing *sunken* countries of Lower Silurian Limestone.

There is no sign of squeeze and distortion along the southern (Greasy Cove) fissure, for the uplifted upper shales abut there horizontally against

the down-thrown limestone prism to the south of it. Whereas in the Embreeville (or northern) fault, the lower part of the shale prism has been lifted and thrust violently against the limestone prism to the north, so as not only to override it, but to curl up the ends of its beds into a collapsed synclinal. The force has therefore come from the south, and acts northward, or north-northwestward. This is not only in accordance with the law of anticlinal structure, made out in Pennsylvania by the survey under Prof. H. D. Rogers, 35 years ago, but with nine-tenths of the fault exhibitions in Virginia and Tennessee.*

What the rock system is, a prism of which has thus been upheaved between the two Lower Silurian districts of Jonesborough to the North, and Greasy Cove to the South, is still a subject for discussion. Mr. Safford, State Geologist of Tennessee, gives it the name of Chilhowee, without identifying it closely with any of the great Formations of the Northern States. It probably underlies immediately the Lower Silurian Limestones.

One thing is remarkable: its apparent total lack of iron ore and limestone. There is no appearance of metamorphism throughout the 6,000 feet of rock trenched by the Nolichuckee.

The cross-fault of Bompas Cove, on the west side of which the L. Silurian Limestones are dropped to water level in an almost undisturbed (horizontal) condition, is, perhaps, the most interesting feature of the dynamic scene I am trying to portray; but it must remain for some geologist to study who has more time at his command than I had, in my hurried visit to Embreeville.

These cross-faults are incidentally mentioned by Mr. Safford, on page 200 of his Report of the Geology of Tennessee for 1869, when he says:

"484. At the ends of these mountains, the sandstones which form them are suddenly and curiously cut off, and wholly disappear. The mountains and their rocks, of course, lie generally immediately on the southeast side of a fault. The sandstones, broken in wide blades, appear to have been thrust up endwise to the northwest, through the overlying formations. The displacement is, in some cases, very great. In the case of Chilhowee Mountain (see section page 190), the sandstones, or, rather, Ocoee conglomerates, have been brought up and abutted against *Carboniferous Limestone.*"

The expressions used in the above description are calculated to obscure the picture to the eye of the reader. The sandstones are prominent objects in the landscape; but they are integral and very subordinate items in the mass of the upthrown (and often but slightly tilled) prism of earth-crust. To a depth unknown to the observer, the earth-crust in all this region of Virginia and Tennessee has been cracked along straight, parallel lines of great length (some of them a hundred miles), but of no

* I have recently exhibited to the Society cross-sections of this structure, in Tazewell, Wise, and Scott Counties, Virginia, which, when published in the next Number of these Proceedings, will make this law sufficiently comprehensible.

great width, seldom over five miles. In Mr. Safford's Section (page 190), across Eastern Tennessee, from the carboniferous table-land, southeastward to the Metamorphic Azoic Mountains of the North Carolina line, 52 miles, there are *eight* of these faults noted, making the average width of each prism (supposing no fault has been omitted) 6½ miles.

The upthrow or override of the side face of each prism against the prism to the northwest of it, varies from fifteen thousand (15,000) feet (as in the Chilhowee Mountain Fault above cited, and in the Montgomery and Wythe County Faults of Virginia) down to five thousand, as in the case of the Embreeville Fault, and others of a like kind, in the same range, where the bottom measures of the Chilhowee, or top measures of the Ocoee, Formations abut against the Trenton Limestones.

The tilt of a prism, five miles wide to an elevation of only one mile on its northwest border, gives an average dip of 1 in 5, or 10°. But the tilt has been produced by a thrust from the southeast, violent enough not only to produce the tilt, and thrust the prism forward and upward, but to rub up the broken edges of the layers of the down-tilted next prism, and to rub down the broken edges of its own layers; and, moreover, to bend the whole body of the prism along its northwestern limit. Consequently we have *there* dips of 45°, whereas the dips everywhere else (with trifling exceptions) are scarcely more than 5°.

It may be said, therefore, if astonishment be expressed at the vastness of these upthrows, considering the weight of the prism, that, in fact, there has not been so much upward movement after all.

On the other hand, in the sections I have made across sets of these faults, in other parts of the region, and where the uptilt is of lower Silurian Limestone against Coal Measures, repeated again and again, the proportion of horizontal to vertical is as 5 miles to 3 miles, and a dip of 30° pervades the entire body of the prism, and of *each* prism, from side to side.

This is a very astonishing state of things. And it characterizes a region of country fifty miles wide by five hundred miles long, roughly stated.

What supports these long untilted prisms of earth-crust?

We cannot imagine an underground Pre-silurian topography arranged with such regularity, as to allow the settlement of the sections of Paleozoic series, in straight lines, hundreds of miles long, and always on one side, the southeastern.

It seems to me evidently necessary to assume a (in some sense) plastic underground, on which these wonderfully regular prismatic rods of Paleozoic rock have been able to roll one-third over and adjust themselves.

The alternative must be, that the vacancies (of triangular section) have been filled with the debris of the lower crushed edges and bottoms of the prisms,—a most unsatisfactory suggestion—especially unsatisfactory, because the regular over-roll of all the prisms in one direction

proves that the laterally acting energy (whatever may have been its origin) was acting on a great plate of Paleozoic rockmass, at least (counting in the coal measures) *four miles thick;* solid, although flexible, itself; but free, when broken, to slide on its foundations, as the broken up flakes of ice slides over the water which supports them.

That there was no absolutely fluid (lava?) underground beneath them is evident from the total absence of volcanic rocks at the present eroded surface, along these faults, even when the uppermost *Subsilurian* rocks appear in one wall. (The numerous warm springs connected with the Virginia faults are explicable on chemical principles, no doubt.) But beneath the uppermost Subsilurians are vast formations, all more or less metamorphosed, and many converted into granites and other crystalline forms. Here we have the plastic mass we need, over the surface of which (of course, an eroded surface, but, probably, eroded to a plane containing no Alpine or even Subalpine inequalities) the Paleozoic deposits, consolidated by time into a consistent, but never yet dried, sheet, seven miles thick in Pennsylvania, five miles thick in Virginia, three miles thick in Tennessee, moved with a certain freedom, under a lateral pressure, from the southeast, at the close of the Coal Era.

I have formerly taken occasion to ascribe the difference of effect exhibited by this pressure in Pennsylvania and in Tennessee to the difference in the thickness of the Paleozoic mass. In Pennsylvania it was folded; in Tennessee dislocated. But the difficulty which pressed on Mr. Rogers to explain the sustentation of the vaults of our Northern anticlinals, is encountered equally by the Southern geologist who will explain the stable equilibrium of his tilted prisms.

To return from this digression to the cross fissures, which cut off the ends of the Chilhowee and other mountains (and an example of them is given in my map of Bompas Cove), it must be understood that they do not obey one law, as do the principal and parallel dislocations of the country. They sometimes run square across from one of these to or towards another; seldom cutting a prism entirely off; usually cracking its north western edge for a certain distance into its body. It is a subordinate and secondary system of faults. But by means of it most of the Appalachian ridges or mountains, of Middle Silurian and Upper Divonian age, are swallowed up and ended at the surface; just as are the mountains of Chilhowee sandstones, in such cases as that described by Mr. Safford above.

The section accompanying my map will, perhaps, be compared by some reader of this paper with Mr. Safford's section on page 202, and they will be seen to be very different. It is only needful to explain that my section was made with instruments on the ground under favorable circumstances, and carefully drawn to the same horizontal and vertical scale; whereas the section on page 202 is like Mr. Safford's other sections, drawn to a vertical scale at least twenty times greater than the horizontal, and, as he says, "it is not intended to be accurate in detail."

In fact nothing can be more erroneous than the impression on the mind

of a young geologist produced by the section. It not only distorts the facts, but bars the way to a right understanding of the structure not only of this locality at Embreeville Gap, but of similar localities along the Unaka Mountain range.* There are no such synclinals as are there represented. There is nothing which in the remotest sense resembles the anticlinal there drawn under the letter D. That interval is essentially and wholly monoclinal.

Every student of American geology must acknowledge his great indebtedness to the assiduous and judicious State Geologist of Tennessee, who has done so much to elucidate one of the most interesting regions of the United States. Among the many valuable columns of thicknesses which he has published, the following (in § 489) justifies the statement I have made relative to the amount of rock visible along the river above Embreeville. It represents the Chilhowee Group, in Doe River Gap, Carter County.

Top of Section:—Quartzose sandstone	55 feet.
Sandstones and Shales	70
Quartzose Sandstone	10
Sandstone and Sandy Shales	250
Quartzose Sandstones	35
Sandstones and Sandy Shales	370
Quartzose Sandstone	40
Thick and thin bedded Sandstone, generally dark colored, occasionally Sandy Shales, and but little fine conglomerate	1,720
Quartzose Sandstone	40
Thin Sandstones and Sandy Shales	320
Sandstones and fine conglomerate with two Quartzose bands	275
Heavy bedded Quartzose Sandstone	38
Sandstone not well seen	180
Heavy Gray Quartzose Sandstone, with unimportant layers of fine conglomerate	60
Sandstones with conglomerate, dark and even bedded	44
Heavy Gray Quartzose rock, mostly sandstones with fine conglomerate	60
Some of the Sandstone hard and Quartzose	472

The lower part of my Embreeville Section consists of between one and two thousand feet of sandy shales, with two very massive plates of conglomeratic sandstone, about twenty feet thick. Two or three thousand

* With the highest respect for the distinguished services rendered our science by the State Geologist of Tennessee, I cannot refrain from expressing regret that the weight of his standing in the science should be thrown into the scales on the side of the slovenly and mischievous fashion of distorted drawing in vogue among geologists until recent years. A section is worse than worthless which is not well and truly drawn. It is sure to manufacture and perpetuate false views.

feet more, higher up, consist of massive sandstones and heavy beds of shale alternating. Just overlying the upper conglomeratic sandstone plate are variegated clay slates.

It is impossible not to see the significance of the immense development of sandrocks and pebble rocks, in the Ocoee and Chilhowee systems, underlying the Lower Silurian Dolomites, and hugging the flank of the backbone of the Continent, for a thousand miles through Virginia, North Carolina, Tennessee and Georgia, as in New Jersey and New York. It is a shore deposit on an immense scale, in a shallow sea, with a steeply inclined margin, and an Alpine range inland. No glaciers; for the conglomerates consist of rolled shingle stones; but torrents, innumerable and vehement. No large rivers; for no delta deposits of any size are apparent. A rapid degradation of the mountains was followed or stopped by a partial submergence, which deepened the sea, made the sand deposits finer, and permitted the deposit of the Lower Silurian limestones.

The reason therefore why the massive Quebec Group (Potsdam, Chilhowee and Ocoee) formation does not come up to daylight in the faults which break the middle and northwestern parts of the floor of the region under discussion, is because it thins away rapidly seaward, that is, westward, towards the Coal Area. And in this it only sets an example afterwards followed by the sandstone and conglomerate members of the great Palæozoic system: Nos. IV, IX, X, and XII the Millstone Grit.

Stated Meeting, July 19, 1872.

Present, five members.

Mr. Eli K. Price, in the Chair.

A photograph for the Album was received from Prof. Thomas Chase, of Haverford, Pa.

Letters acknowledging receipt of publications were received from the Royal Society, London (86, 87). The Royal Saxon Society (86); the Zoologico-Botanical Society, Vienna (Vols. 8 to 11 Proc., and Trans. Vols. XII, XIII, XIV, i, ii, with a request to have the set completed. On motion, referred to the Librarian); and from Dr. Hornstein, Prag. (86).

Letters of envoy were received from the Observatorio de Marina de S. Fernando, and the Physico-Medical Society in Erlangen.

Donations for the Library were received from the Belgian Academy, French Geographical Society, Italian Geological Commission, London Chemical, Geological, Asiatic and Antiquarian Societies, Meteorological Office, Nature, Old and New, Dr. Samuel Green, Silliman's Journal, American Chemist, Philadelphia Academy of Natural Sciences, Franklin Institute, Penn Monthly, American Journal of the Medical Sciences, Medical News, Baltimore Peabody Institute, Washington Philosophical Society, and Petroleum Monthly.

A paper entitled "On the Tertiary Coal and Fossils of Osino, Nevada," by Prof. Cope, was referred to the Secretaries.

Prof. Chase read a paper on "Ætherial Oscillation, the Primordial Force," and stated that certain of his predictions had been verified, which were based on his observations of the rainfall at San Francisco.

Pending nominations, Nos. 693 to 697, and new nomination, No. 698, were read.

Nominations, 693 to 696, were balloted for, and the following persons declared duly elected members of the Society:

Rev. Starr Hoyt Nichols, of Philadelphia.

Mr. Coleman Sellers, of Philadelphia.

Dr. Robert Peter, of Lexington, Kentucky.

Dr. Richard J. Lewis, of Philadelphia.

And the meeting was adjourned.

Stated Meeting, August 15, 1872.

Letters of acceptance was received from Dr. Robert Peter, dated Lexington, Ky., August 8th, and Mr. F. B. Miller, dated Royal Mint, Melbourne, May 6th, 1872.

Letters acknowledging receipt of publications were received from Mr. Peter Turner, dated Leoben, Oct. 12, 1871

(83, 84, 85); the Observatory at Prague, June 12, 1872 (86); the Royal Society, Rotterdam, Aug. 1, 1872 (86); the Royal Society, Stockholm, May 8, 1872 (XIII, i, ii, iii, XIV, i, ii, 71 to 77, and 80 to 85), and the Royal Society at Upsal, April 15, 1872 (XIV, i, ii, 83 to 85.)

Letters of envoy were received from the Royal Societies at Upsal and Stockholm, April, 1872; the Observatory at Turin, May 12, 1872, and the Hungarian Academy at Perth, Sept. 16, 1871.

Donations for the Library were received from the Hungarian, Prussian, Swedish, Belgian, and American Academies of Science; the Sociėties at Moscow, Upsal, Copenhagen, Bremen, Frankfort, Offenbach, Lausanne, Liverpool, and Salem, Mass.; the Bureau des Ponts, Montsouris Observatory and Revue Politique at Paris; the Royal Astronomical, Geographical and Asiatic Societies at London; Nature, the Public Library and Old and New at Boston; the American Journal of Science, Prof. Dana and Prof. Marsh, at New Haven: the New York Lyceum, Prof. James Hall and R. P. Whitfield, at Albany, the Franklin Institute, Journal of Pharmacy, Medical News and Penn Monthly, at Philadelphia: and the U. S. Bureau of the Interior.

The Librarian announced the reported death of Mirza Alexander Kasem Beg, Dr. Bujalsky (1866), and D. C. Dworjak, of St. Petersburg, members of this Society.

The following communications were received from Prof. E. D. Cope:

On a New Genus of Pleurodira, from the Eocene of Wyoming.

Descriptions of New Vertebrata, from the Bridger Group of the Eocene.

Second Account of New Vertebrata, from the Bridger Eocene.

And the meeting was adjourned.

DESCRIPTIONS OF SOME NEW VERTEBRATA FROM THE BRIDGER GROUP OF THE EOCENE.

BY E. D. COPE.

(*Read before the American Philosophical Society, August* 15, 1872.)

MESONYX OBTUSIDENS. Cope.

Represented by a large part of the skeleton of an individual of about the size of the wolf (*Canis lupus*). The lumbar vertebræ display the short acuminate, and anteriorly directed diapophyses, characteristic of carnivora, while the astragalus resembles that of the same group. The claws are flat and not curved. The molar teeth exhibit two principal lobes and a thin rudimental at one extremity. The middle lobe is a compressed cone, the posterior, a cutting edge, but medially placed, and less acute than in *Hyænodon*, and the sectorial teeth of other carnivora, forming a less specialized cutting apparatus. The canines are well developed. A premolar is stout conic, with rudimental tubercle at base.

	M.
Length of a sectorial (crown)	0.018
Greatest width	.008
Elevation of crest	.006
Length of crown of a second	.015
Width	.0065
Elevation of middle lobe	.014
Length of crown of canine	.026
Diameter near base	.014

The number of the teeth cannot be determined, owing to the injured condition of the jaw bones. The enamel is entirely smooth.

Found on the bluffs of Cottonwood Creek, Wyoming.

TRIACODON ACULEATUS. Cope.

Established on two teeth of the molar and premolar series. The molar is subtriangular at the base of the crown, one side being convex; the opposite angle nearly right, and the two remaining sides flat. The crown is divided into three elevated trihedral cones, one at each angle. Their adjacent angles are acute, and the angle of union is fissured, like the same point in the sectorial tooth of a carnivora. The smaller lobes are of equal elevation, but the crown of one is expanded so as to be slightly spade-shaped. The enamel is smooth.

	M.
Elevation of highest cusp	0.009
" " shorter "	.007
Long diameter base of crown	.006
" " " flat side	.005

The premolar is smaller, with shorter cusps, and one of the laterals reduced to a rudiment.

This species is near the *T. fallax* of Marsh, but the tooth he describes is narrower in proportion to its length, and has the anterior lobe little over half as high.

HYOPSODUS PYGMÆUS. Cope.

Represented by a portion of the right mandibular ramus with the penultimate and ante-penultimate molars in perfect preservation. These teeth present four cusps, of which the inner are crescentoid in section, the outer conic. They are all elevated, and the outer anterior is in both teeth compressed and bifid; it receives an oblique ridge from the inner posterior. Enamel smooth.

	Lines.
Length penultimate molar.	2
Width.	1.5
Depth of ramus at do.	3

This is a small species of the genus, being about equal to the *Hyopsodus paulus* L. The penultimate molar in the allied species, *Lophiotherium ballardii*, Marsh, measures 3.2 lines in length.

ANOSTIRA TRIONYCHOIDES. Cope.

This species is about the size of our existing *Chrysemys picta*. It differs from the *A. ornata*, Leidy, in various respects. Thus the sculpture of the costal bones is pit-like, as in some species of *Trionyx*, instead of striate-ridged. There is no keel on the pygal bone behind. The first marginal bone is longer, and does not exhibit the prominent shoulder seen in *A. ornata*. The marginal bones are not unlike those of that species, having central small tubercles, and radiating ridges. The species is not uncommon in the Bridger beds on Cottonwood Creek, Wyoming.

ANOSTIRA ŒDEMIA. Cope.

This species is nearly twice the size of the last. It is distinguished by its peculiar ornamentation. This consists of bosses or swollen portions of an oval shape, which stand transversely to the long axis of the body, from a quarter to a half an inch apart. They sometimes form short ridges, surface otherwise smooth. Locality same as the last species.

ANOSTIRA MOLOPINA. Cope.

This species is intermediate in size between the two last described. It is distinguished from both by its ornamentation. This consists of a delicate and rather scattered impressed punctation, on the costal bones. Across this extend oblique ribs extending in a diagonal direction outward near the extremities of the costals. The width of one of the costals is M. .023. The costals in this species display no suture for the marginals, and the extremity of the rib projects a very little.

TRIONYX CONCENTRICUS. Cope.

This species is not uncommon in the Bridger sandstone. It is well characterized by its sculpture, which is coarsely and distinctly pitted. Across the costal bones run parallel ribs, which enclose between them from three to one row of pits.

	M.
Width of a costal bone near the middle	.02
Thickness " " "	.003

The carapace is thin. Besides being smaller than the *T. guttatus*, Leidy, this species differs in its longitudinal ribs.

TRIONYX THOMASII. Cope.

This tortoise is again distinguished from all those known by its sculpture, this being very delicate and obscure when compared with the thickness of the carapace. It consists of small tubercles of more or less elongate form, which may or may not inosculate; eight may be counted in M. .01. Width of a marginal costal, .02; thickness on suture, .0055. So in *T. concentrica*. The costals have very little curvature. The faintness of the ornamentation is a marked character.

Dedicated to my former teacher, Joseph Thomas, M. D., author of Lippincott's Biographical Gazetteer, the Pronouncing Gazetteer of the World, Baldwin's Gazetteer, and other important works.

Found with the *T. concentrica*, on Cottonwood Creek, Wyoming.

AXESTUS BYSSINUS. Cope

Genus et species novæ Trionychidarum.

This genus is represented by a species which is allied to *Trionyx*, but which differs in some important respects. The sternal bones are provided with an enamel stratum exterior to the usual dense layer of the bone, which is not sculptured. The post-abdominal bone has no sutural connections, but sends out tooth-like processes at its angles. The caudal vertebræ are procœlian, furnished with stout diapophyses and not very elongate; ball depressed, undivided. The cervical vertebræ are elongate and relatively very large. The claws are very large, and one at least flat and straight; the phalanges have broad trochlear surfaces, which indicate a moderate amount only of vertical movement. Both humerus and femur are curved and with extensive trochanters. The procoracoid and scapula are of equal lengths and the coracoid is much dilated distally.

Char. specif. The portions of plastron preserved are thin for the size of the animal, and all the bones are especially dense and smooth. The (?) post-abdominal has the free margins acute and serrulate. There is an (?) external gently convex edge with a long process extending backwards; and one long narrow one inwards. The enamel is white and is marked with decussating lines of osseous deposit, as in woven linen. This is not the result of wearing. The cervical vertebra is without spine; it is compressed in the middle and is without any pneumatic foramen.

	M.
Length cervical vertebra	.068
Diameter at middle	.020
" " end	.035
" caudal do. at ball	.010
Length " "	.023
" of an ungueal phalange	.043
Proximal depth do.	.013
Length post-abdominal (broken)	.180
Width do.	.120

Locality of the last.

BAENA HEBRAICA. Cope.

Established on a large and nearly complete fossilized tortoise, which lacks the posterior lobe of the plastron, and a corresponding part of the carapace. The component elements are coössified.

The costal scuta are very wide, excepting the first pair, whose posterior margin is sigmoidally flexed. The anterior vertebral is concave behind, and has convex lateral margins. The marginal scuta in front are very narrow, but the fourth on each side is suddenly widened in front to meet the suture between the first and second costal scuta. The sutures are all perfectly regular. There are only four inframarginal scuta, of which the second from front is the largest, forming, with the third, an angle projecting inwards.

The carapace and plastron are smooth, excepting in the lines of the sutures of the costal bones. In this position there is, in each case, a series of short pit-like grooves parallel to each other, and transverse to the axis of the bone, forming figures like some Hebrew letters, the Greek *Π*, etc.

The borders of the carapace are obtuse, and the general form is almost round. The diameter is almost eighteen inches.

This species may only be compared with the *B. undata*, Leidy, with which it agrees in having the humeral scuta crowded to the front of the plastron, and having a common centre with the gulars, which they little exceed in size. It differs in having four instead of five inframarginals, regular sutures, a differently formed first costal, wider lateral marginals, and in the smooth carapace with the peculiar sculpture mentioned.

TESTUDO HADRIANA. Cope. Spec. nov.

Indicated by two individuals, one nearly perfect, the other chiefly represented by a complete plastron.

This proves the existence of a very massive species of the terrestrial genus Testudo. The plastron presents a short wide lip in front, which is turned outwards, forming a strong angle with the plane of the upturned front of the lobe. This lobe is bordered by a thickening of the upper surface, which cuts off the basin from the lip, as a high ridge. The posterior lobe is deeply bifurcate, each post-abdominal projecting as a triangle. There is a notch at the outer angle of the femoral scute. The hyposternal bone is greatly thickened within the margin above, and an elevated ridge bounds the basin of the plastron behind, as before. The middle of the plastron is thin.

The carapace is without marked keel or serrations. It is remarkable for its expanded and truncate anterior outline, which is nearly straight between two lateral obtuse angles.

Length carapace, M. .750 = 29 inches; width, .630.

The marginal scuta are narrow, and there is a large nuchal plate.

Same locality as the last.

PALÆOTHECA POLYCYPHA. Cope.

This genus and species of tortoises are indicated by vertebral, costal

and marginal bones of very small individuals. These bones are, however, not only thoroughly ossified, but are very stout, indicating the adult age of the animal. The deeply impressed scutal sutures and heavy proportions, as well as the elevated carina of the carapace, indicate affinity with *Cistudo*, or perhaps, *Testudo*. As another generic character, it may be noted that the vertebral bones are subquadrate, and support the neural canal without intervening lamina.

The carina of the carapace is abruptly interrupted occasionally ; sometimes with, sometimes without, a pair of pits, one on each side. The marginal bones are well recurved, and the scutal sutures are deeply impressed on them.

	M.
Length of vertebral bone	.009
Width " "	.0085
Length marginal "	.01

This is the least of the tortoises of the Bridger Formation.

PALÆOTHECA TERRESTRIS. Cope.

Represented by three individuals, one of which may be regarded as the type. They are all thinner than the *P. polycypha*, and larger, being about equal to the *Aromochelys odoratus* of our ponds.

In the type specimen the carina of the vertebral bones is interrupted by a deep sutural groove, which is less pit-like than in *P. polycypha*. The bone itself is broader than long, being, perhaps, from the hinder part of the carapace. The clavicular (episternal) bone is preserved. It is characterized by the considerable and abrupt projection of that part enclosed by the gular scutum, which resembles what is sometimes seen in *Testudo*. The edge of this part is entire and acute. The posterior part of the projection forms a step-like prominence behind, on the superior or inner face. The bone is almost as wide as long, and the mesosternal causes a very slight median truncation, but overlapped much on the inner side. The gular dermal suture does not reach it.

	M.
Length vertebral bone	.009
Width " "	.018
Length episternal	.02
Width " (transverse to axis of body)	.017
Width of a costal	.011
Thickness proximally	.003

In a second specimen, a strong groove is seen to bound the lip of the front lobe of the plastron as in the species of *Notomorpha*. In it the marginal is seen to be stout, a little recurved, and sharp-edged. A vertebral differs from those described in being longer than wide.

In a third individual the gular lip is not so prominent as in the type, and the mesosternal bone truncates the clavicular extensively giving it thus a more elongate form. The gular scuta expands to its front margin. The marginal bone is stout and sharp edged, and is not so deeply impressed by the dermal suture, as in *P. polycypha*.

Length episternal	.016
Width "	.026
Length marginal	.011
Width "	.016

The three specimens are from the bluffs of Cottonwood Creek, Wyoming.

NAOCEPHALUS PORRECTUS. Cope.

Gen. et. sp. nov. Lacertiliarum.

Established on an incomplete cranium, with vertebræ found associated. No teeth are preserved, nor any part of the mandible. The remaining portions of the cranium are, however, highly characteristic.

The occipital descends posteriorly, and bears a pair of lateral ridges, which converge rapidly posteriorly. This bone is united with the parietal by suture, which is transverse; its outline is rectangular, so as almost to reach the frontals, which are prolonged backwards on each side the parietal, leaving but a narrow exposure of the posterior processes of the parietal. These extend backward, and are broken off in the specimen, but they probably formed parts of arches. The parietal is single, and there is no parietal fontanelle. The bone is triangular in outline with the apex anterior, dividing the frontals. These are contracted at the orbits, and have a projecting superciliary head; anteriorly they are thickened. The postfrontals are of remarkable form. They are massive, and compressed from before backwards; they rise considerably above the level of the front, and bear on their summits a cotyloid cavity, which is transverse to the axis of the cranium; the use of this projection is obscure. There is an exoccipital foramen, and a large one in the posterior part of the frontal opposite the postfrontal elevation.

The sphenoid is a compressed keel-shaped bone, rounded below, and with broad alæ along much of its length. The occipital condyle is subcordate depressed in outline, with a vertical obtuse angle in the middle and the sides somewhat plane.

A dorsal vertebra preserved has a single vertical capitular process, and a short hypapophysis. The neural canal is large, and the neurapophyses are attached by sutures. The cup is nearly round, very slightly transverse, and in vertical plane.

The cranium is smooth above, except the anterior part of the frontals, which are finely rugose.

This genus is more or less allied to the *Thecoglossa*, but better material will be requisite to decide the question of affinities fully.

Found with the preceding specimens.

	M.
Width cranium at postfrontals	.072
" parietal behind	.012
Depth postfrontal	.018
" pre-sphenoid anteriorly	.014
Diameter dorsal vertebra (cup)	.007

This genus differs from *Glyptosaurus*, Marsh, in the total lack of cranial shields, and from *Saniva*, Leidy, in the nearly round vertebral centra.

SECOND ACCOUNT OF NEW VERTEBRATA FROM THE BRIDGER EOCENE.

By Edward D. Cope.

(*Read before the American Philosophical Society, August 15, 1872.*)

Helotherium procyoninum. Cope. Spec. nov.

This species is distinguished from those already known as pertaining to this genus, by its small size, as it did not much exceed the raccoon in dimensions. The size of a right superior molar is as follows:

	M.
Length	0.007
Width posterior	.0085
" anterior	.006

The crown presents four tubercles, of which the inner are flat on the posterior, the outer flat on the external side. The posterior external has a small posterior supplementary lobe, and a low tubercle intervenes between the two posterior. An anterior and a posterior cingulum. Enamel smooth.

Stypolophus pungens. Cope.
Gen. et spec. nov.

This genus is supposed to embrace a small species of carnivorous animal found by the writer in the Eocene formation of the Bridger Group. It is represented by the posterior portion of the left mandibular ramus, which contains the last two molars.

The generic characters are seen in the composition of these molars, which have but two roots, and a posterior table, as is seen in tubercular molars of some *mustelidæ*. The anterior two-thirds of the crown is composed of conic cusps. On the last molars these are in two series, two lower, of the inner, and one more elevated, of the outer, opposite the interval between the outer. Its outer face is regularly convex, but its posterior forms, with that of the outer series, a single flat vertical plane, which forms a sharp angle with the inner and outer faces of the cusps.

The structure is, in general, somewhat like that of *Mesonyx*, Cope, but the lack of cutting edge on the posterior lobe, and the two rows of tubercles separates it at once. Dr. Leidy describes *Sinopa* as having a sectorial tooth, as in ordinary *Carnivora*, with an interior cusp, hence it is not probably the present form, although this species was about the size of the *S. rapax*.

The enamel is smooth. The measurements are:

	M.
Depth ramus at last molar	0.011
Length last molar	.0072
Width " posteriorly	.0040
Height inner tubercle	.0062
" external " (anterior)	.0040

This species was about the size of the gray fox.

From the bluffs of Cottonwood Creek, Wyoming.

PANTOLESTES LONGICAUDUS. Cope.

Gen. et sp. nov.

This form is one of those mixed types which are so abundant in the Bridger Group. Its dental formula is M. 3, P. M. 3; c. 1, incisors unknown. The molars in the only specimen known are so worn as to preclude exact description. They evidently possessed anterior and posterior lobes, separated by a valley, which was most expanded on the inner side. The last molar exhibits a projecting keel posteriorly, which probably supported a small tubercle. The three premolars are all two-rooted and compressed in form. The last presents a crown composed of one large anterior compressed cusp, and a much lower posterior one. There is a slight cingulum in front. The canine is lost, but its alveolus indicates that it was a stout tooth.

So far as the known dental structure goes, this genus resembles nearly the *Notharctus* of Leidy (*Limnotherium* of Marsh), but possesses one premolar tooth less.

The mandibular ramus is quite slender, and there is a large foramen below the first true molar. The masseteric fossa is pronounced.

	M.
Length of dental series to canine	0.0280
" " three molars	.0140
" " second "	.0041
Width " " "	.0030

There were found associated with this jaw some caudal vertebræ of very attenuated form, which point to the possession of a long tail by this animal. One of these displays six short processes arranged round the articular extremity, the neural arch not being completed.

	M.
Length	0.016
Proximal diameter	.003
Median "	.0018

PSEUDOTOMUS HIANS. Cope

Gen. et sp. nov.

This form is interesting as the only member of the Edentate order yet discovered in our earlier Tertiary formations. It is represented by a species of which a nearly perfect cranium is in my possession. This is about the size of an agouti, and is of a depressed form. It has a thin molar and zygomatic arch, but no postorbital. There is a large suborbital foramen. The dentition consists of two pairs of long curved teeth, having much the form and position of the cutting teeth of *Rodentia*. These are placed widely apart in the upper jaw, allowing space for the greater portion of the premaxillary between them. The mandibular cutters are less widely separated by a narrow prolongation of the symphysis. The exposure of the tooth is lateral, its direction nearly anterior. It projects anteriorly very little beyond the symphysis, and has a horizontal triturating surface below the level of the latter. Neither pair of cutting teeth

are faced with enamel, but have only smooth cementum without sculpture. There are no molars, but the inferior face of the maxillary bone is rugose as though alveoli had been absorbed. There are traces of very shallow alveoli.

The cast of the brain indicates smooth oval hemispheres which leave the cerebellum and olfactory lobes entirely exposed. The latter are ovoid and expanded laterally.

The cranium is depressed, and has a trace of interparietal crest. The anterior margin of the temporal fossa is marked by a curved angle on each side of the frontal bone. The supra-orbital arch is very short.

This curious animal reminds me of a small *Megalonyx* with flattened cranium. The cutting teeth above are, however, more like those of rodents.

	M.
Length cranium (3.5 in.)	0.090
Width " (without zygomas)	.040
" " near end of nasals	.027
" upper cutting tooth	.007
Depth " " "	.0085
Length exposed part lower tooth	.009
Width " " " "	.006

HADRIANUS OCTONARIA. Cope.

Gen. et sp. nov.

This is a genus of true *Testudinidæ*, designed to include those with double anal scuta, and posterior lobe of the plastron bifurcate. In addition to the species above named, the *H. quadratus* (*Testudo hadriana*, Cope), and probably the species to which belongs a small piece named by Leidy, *T. corsoni*, pertain to the genus.

The *H. octonarius* is distinguished from its congener in many ways. It is of elongate form, strongly contracted at the bridges, but expanded and arched above the limbs. The carapace in quite convex. The plastron has the posterior lobe emarginate rather than bifurcate, as seen in *H. quadratus*. Each projection represents a right-angled triangle rather than a wedge. The anterior lobe presents an elongate lip, which is expanded, and slightly emarginate at the end. The mesosternal bone is heart-shaped, the posterior emargination being wide and deep.

The anterior margin of the carapace is somewhat flared above the limbs. The nuchal scutum is very narrow transversely, but elongate. The carapace descends and is incurved in the middle of the posterior margin.

	M.
Length (below)	.730
Width at middle	.437
" at hind limbs	.525

This species differs from the *H. quadratus* in many important points. It is perhaps the largest of our extinct land tortoises, and is founded on a beautifully perfect specimen from the bluffs of Cottonwood Creek.

THIRD ACCOUNT OF NEW VERTEBRATA FROM THE BRIDGER EOCENE OF WYOMING TERRITORY.

By Edward D. Cope.

(*Read before the American Philosophical Society, September* 19, 1872.)

Stypolophus insectivorus. Cope. Sp. nov.

Represented by a posterior molar and a premolar of the right side of an animal less than half the size of the *S. pungens*, Cope. The molar presents three anterior trihedral acute tubercles, of which, one is exterior and more elevated than the others. Its posterior plane forms one transverse face with that of the inner posterior. The posterior tubercular heel is low, and supports an oblique ridge which bounds a deep groove behind the outer cusp, no doubt to receive that of the upper jaw. This arrangement is not seen in *S. pungens*. The premolar is a flat cone with faint traces of a tubercle behind and cingulum on inner side.

	M.
Length crown molar	0.0050
Height inner cusp	.0040
Length heel	.0025
Width crown	.0030
Height crown premolar	.0040
Length " "	.0040

Found in the Eocene Bad Lands of Black's Fork, by the writer.

Stypolophus brevicalcaratus. Cope. Sp. nov.

Established on a portion of the left mandibular ramus, containing the penultimate and ante-penultimate molars, of an animal of larger size than the type of the genus *S. pungens*. The molars have the general characters of the corresponding ones of that species, but differ in their greater elevation in comparison with their length, and the greater convexity of the outer side. The shortness is occasioned by the abbreviation of the heel, which in the last molar present, is very small and flat, without keel or tubercle on its surface. That of the molar preceding it is larger. and presents in its elevated outer margin, a trace of the keel seen in the smallest species. Enamel smooth.

	M.
Length of two molars	0.016
" " penultimate crown	.008
Width " " "	.0047
Length " " heel	.002

There is some relation between *Stypolophus* and *Triacodon*, Marsh. If the heel of the molars of the former were wanting, they would be those of the latter. The premolars might be supposed to have this structure, but the form seen in *S. insectivorus* disproves this view. In fact, I have seen both molars and premolars of *Triacodon aculeatus*, Cope, and the former lack the heel of the *Stypolophi* entirely.

MIACIS PARVIVORUS. Cope. Gen. et sp. nov.

Established on a portion of the right ramus mandibuli, containing portions of three molars, the penultimate being perfect. As in *Canidæ*, the molars diminish in size posteriorly, the last being single-rooted, the penultimate being two-rooted. The structure of that tooth is approximately that of *Stypolophus*, *i. e.*, with three trihedral cusps in front and a heel behind, but the cusps are of equal height, and their point of union not raised above the surface of the heel. This is a valley bounded by a sharp margin which is incurved to the outer cusp, leaving a vertical groove on the outer side, as in *Stypolophus* sp. This genus further differs from that one in the single-rooted small tubercular posterior molar, which is wanting in that one. The ante-penultimate molar is much larger than the penultimate. The crown of the latter is laterally expanded, and bears a cingulum at the base antero-externally. Enamel smooth.

	M.
Depth ramus at penultimate molar	0.0080
Length crown of " "	.0040
Elevation " " "	.0025
Width " " "	.0033

Found on Black's Fork of Green River. An ally of *Stypolophus* and *Triacodon*.

TOMITHERIUM ROSTRATUM. Cope. Gen. et sp. nov.

Allied to *Notharctus*, Leidy. Dental formula $\frac{?}{2}\frac{?}{1}\frac{?}{4}\frac{?}{3}$, in an uninterrupted series. Last molars with five tubercles, others with four; all low and slightly alternating, the outer wearing into crescents. Canines quite small. Incisors very prominent, the median pair with transverse cutting edges. Symphysis coössified, projecting in front.

I base the distinction between this genus and *Notharctus* on the small canine, and the sub-horizontal position of the incisors; believing that when other portions of the skeleton are studied, other differences will appear. This, I have the opportunity of doing with material now in my hands.

The adjacent horns of the two outer crescents unite with the anterior outer tubercle; the posterior outer is insignificant. There is a projection but no tubercle in front of the outer anterior tubercle. The first and second premolars have but one root, the base of the second being about the size of the base of the canine. The latter are cylindric at base. The incisors form a parabolic outline, and have entire edges, the middle pair transverse ones. Enamel generally smooth, premolars somewhat striate; an indistinct inner cingulum.

	M.
Length of entire dental series (straight)	0.044
" symphysis mandibuli	.030
Depth ramus at second molar	.010
Length crown of " "	.006

	M.
Width crown of second molar	.0045
" between two " "	.014
" " " canines	.005

From near Black's Fork of Green River.

I would refer to *Notharctus*, my *Lophiotherium vasachiense*, adding the fifth species to the genus. These are *N. gracilis*, Marsh, *N. tyrannus*, Marsh, *N. tenebrosus*, Leidy, *N. robustior*, Leidy, and *N. vasachiensis*, Cope.

HADRIANUS ALLABIATUS. Cope.

This large land tortoise is nearer in general form to the *H. quadratus* than to the *H. octonarius*, but differs from both in the absence of the projecting lip of the anterior lobe of the plastron, which is thus simply truncate. The mesosternum is not cordate, but has much the shape of that of *H. quadratus*, that is, rhombic. The scutal sutures are deeply impressed. The plastron is strongly concave. Carapace without irregularities of the surface. Length eighteen inches.

From the Bad Lands of Cottonwood Creek, Wyoming.

EMYS LATILABIATUS. Cope.

Represented by a perfect specimen of a tortoise of a broadly oval form, and somewhat terrestrial habit. Its prominent characters are to be seen in the plastron, of which the posterior lobe is deeply bifurcate. The anterior lobe is peculiar in the unusual width of the lip-like projection of the clavicular ("episternal") bone, which is twice as wide as in *E. Wyomingensis*, and not prominent. Bones all smooth; margins of lobes of plastron thickened. Length of shell, one foot.

	M.
Width of lip of plastron	.06
Depth of posterior notch	.02

From near Black's Fork of Green River.

PROTAGRAS LACUSTRIS. Cope.

Gen. et sp. nov.

A serpent of about the size of the existing "Pine Snake" (*Pityophis melanoleucus*), and allied to the water-snakes of *Tropidonotus* and allied genera.

A vertebra before me has the longitudinal hypapophysial groove of that group, which terminates in a very obtuse point. The ball looks extensively upwards. The upper articular extremity of the parapophysis is short and obtuse, and the inferior equally so, and directed shortly downwards. The articular face being continuous with each other. It sends an obtuse keel backwards, which terminates in front of the ball. The angle connecting the diapophysis and zygapophyses is strong, while the former was narrow ; in the specimens it is broken.

	M.
Length of centrum below	0.009
Depth to base neural spine, in front	.011
Width cup	.0054
Depth "	.0045
Expanse parapophyses above	.012
" " below	.008

From the Bad Lands of Cottonwood Creek, Wyoming.

ON A NEW GENUS OF PLEURODIRA FROM THE EOCENE OF WYOMING.

By Edward D. Cope.

(*Read before the American Philosophical Society, Aug. 15, 1872.*)

The following observations are made with a view of establishing the stratigraphic position of the genus of tortoises described below. They were made by the writer while prosecuting a palaeontological investigation of the Tertiaries of Wyoming for Dr. F. V. Hayden's Geological Survey of the Territories.

The strata exposed along the northern and eastern shores of Bear River, consist of alternate sandstone, argillaceous, and conglomerate rocks of the Wahsatch Group of Hayden. They dip to the northeastward. At the coal mines below (*i. e.*, N. W. of) Evanstown, the series is capped by a heavy bed of conglomerate. At a point seven miles above (*i. e.*, S. E. of) Evanstown, the strata appear in the following order: (1.) an argillaceous rock just appearing above the river level at high water; (2.) 25 feet of sandstone; (3.) a nodular argillaceous rock of a red and ochreous color, 15 feet; (4.) 10 feet of coarse conglomerate; (5.) 80 feet of sandstones and clays.

At a point eleven miles above Evanstown, the conglomerate has descended from view, and the bluffs of 300 feet in height, consist of the upper members of the group, viz.: red and white argillaceous beds; sandstone four to six feet in thickness; a red and white argillaceous stratum, at least forty feet; sandstone 3-4 feet, and a capping of a hard, brittle, ash-colored clay rock on the highest points. Ascending five miles further to the N. E., the strata are observed to dip in a direction opposed to those at Evanstown, rising gently to the N. E. One of the heavier sandstone strata is exposed about half way up the bluffs, and is visible in the side ravines. Crossing one of these, and climbing the opposite spur, a sandstone identical lithologically with those just described, is seen standing vertically; and succeeding spurs are crowned with the edges of the succeeding sandstone beds standing high in the air. Nearly opposite Beartown, a mile eastward on the Union Pacific Railroad, these vertical sandstones pass into a conglomerate, one of the strata being composed equally of both, a gradual lithological transition being exhibited.

The nature of the flexure of these strata is somewhat obscure. The succession of vertical strata is quite similar to that already noted as seen in the bluffs of Evanstown, and the conglomerate would thus be regarded as the superior member. Dr. Hayden, however, describes them as contiguous to cretaceous strata further east.

We are assisted in concluding as to whether these beds which descend abruptly belong to the Wahsatch Group, by a consideration of the curious strata exhibited in the two railroad cuts just N. W. of Beartown, already described and figured by Dr. Hayden, in his report on the Geology of Wyoming, 1870, p. 150–153. In these, numerous thin strata, horizontal on the western end of the exposures, are suddenly decurved and become vertical to the eastward, both directions coinciding with those of the heavier and higher beds which compose the bluffs and ridges just described. That the whole is an anticlinal with the opposite strata of a very unequal dip, is rendered probable by the miniature exhibition seen in the section of the lower beds in the railroad cut.

The Wahsatch beds have been described by Dr. Hayden as wanting in vertebrate fossils. My assistant, Professor Garman, and myself succeeded, however, in discovering a number of species in the upper red and white strata on the bluffs eleven miles S. E. of Evanstown, or near the bend of Bear River. They occurred here on the upper, and upper middle portions, of the exposure. Extending our observations to the ridges of bluffs further to the southward, we found the same strata producing similar, and in several cases the same, fossils. They appeared lower down on the exposures, consistently with the dip of the strata, though a few were found near the top of these, also.

The species obtained were as follows :

1. Part femur of an ungulate, as large as *Palæosyops paludosus.*
2. End tibia of a Perissodactyle mammal.
3. *Notharctus vassacciensis*, Cope, sp. nov.
4. Dermal scuta of crocodile.
5. Fragments of a Crocodilian, perhaps *C. xiphodon.*
6. Fragments of a *Trionyx*, near *Tr. guttatus.*
7. *Notomorpha testudinea*, gen. nov. of tortoises.
8. " *gravis*, sp. nov.
9. " *garmanii*, sp. nov.
10. Fragments of an unknown reptile.
11. *Lepidosteus* scuta, perhaps like *L. glaber.*

12 and 13. Two species of Unio.

The specimens are all more or less fragmentary, and vary in color from nearly white to iron-rust color. The only ones whose specific characters are sufficiently preserved for description are those of the new genus *Notomorpha.* The facies resulting from the association of *Lepidosteus, C. xiphodon* and the mammals, is that of the Eocene of the Bridger Group on the eastern side of the Wahsatch. The new genus described has no Tertiary or Cretaceous relationships ; yet the only Pleurodira yet

found on this continent are Cretaceous, and the mode of attachment of pubis in these species resembles nearly that seen in *Notomorpha*, both differing from most recent genera in this respect.

NOTHARCTUS VASACCIENSIS. Cope. sp. nov.

Represented by a portion of the left ramus of the lower jaw, containing one tooth in perfect preservation. The structure of this indicates it to be the second true molar, and presents certain features of distinction from the same tooth of the *Lophiotherium sylvaticum*, described by Dr. Leidy. The crown presents four tubercles which are arranged in pairs, the separation between the right and left lobe of each being slight, thus giving the tooth the appearance of having two transverse crests as in *Hyrachyus*. The two anterior and outer posterior tubercles are fissured by wearing, but the inner posterior consists of two acute crests which meet, presenting an acute angle towards the adjoining tubercle. The outer posterior tubercle sends a descending crest obliquely to the base of the inner anterior tubercle as in *L. sylvaticum*. A small tubercle occupies the space behind the interval between the posterior tubercles and gives origin to a cingulum which passes round the bases of the outer tubercles. It extends round the front of the tooth to the outer anterior tubercle. Wear would produce small angular crescents from the two posterior and the outer anterior tubercle. Greatest length of crown, M. 0.008; width, .006. The enamel of the tubercles is rugose.

This ungulate was of about the size of the *L. sylvaticum*, or equal to the raccoon. It differs considerably from that species in the less isolation of the tubercles of the molar, and the crescentic form of the inner posterior.

Found by Samuel W. Garman, in the strata of the Wahsatch Group, N. E. of Evanstown, Wyoming.

NOTOMORPHA. Cope.

This form is one of the *Pleurodira*, and differs from most of those already known in the recent and fossil states, in having many features relating it to a terrestrial rather than an aquatic life. The elements of the carapace and plastron are massive, and the former was well arched: both exhibit well defined grooves for the sutures of the dermal scuta. The mesosternum is broad ovate, and the bones of the plastron are united by immoveable sutures. The elevated lateral processes of the hyo and hyposternal bones, are not broad, and unite by suture with the lower plate of the first and last bridge-marginal bones. They are thus recurved in both cases, but none of the ribs indicate any sutural union, as is seen in various genera. The costal bones unite with the marginals by serrate suture.

In one species a large intergular scutum has left its impression, the gulars being lateral and rather small. The anterior lobe of the plastron is emarginate.

The sutural union of the pubis with the xiphisternum is by an elongate

groove in a longitudinal elevation of the bone, much as in the Cretaceous genus, *Taphrosphys*, Cope. The point of attachment of the ischium is not observed nor is the posterior lobe of the plastron observed in any of the specimens. The external part of the hypoxiphisternal suture extends very obliquely backwards. The pubic suture-groove diverges very little from a line parallel with the common xiphisternal suture.

Of limb bones several fragments were found in connection with the *N. testudinea*, but are too large to be referred to that species. One is the extremity of a femur, which had a round shaft and but little curvature. The other is a proximal end, with a flat, wide trochanter, separated from the head by a deep notch, and with a slender curved shaft.

The genera of Pleurodira, which simulate land tortoises most, are found in Africa. They are *Sternothærus* and *Pelomedusa*. They are different enough from *Notomorpha*, the former in its hinged, ten-plated plastron, the latter in its intercalated bone of the plastron. The present form is, therefore, of interest in various ways. It is the first Pleurodira tortoise found west of New Jersey, and is the first of that division known to exist in the Tertiary formations of North America. As compared with those from the Cretaceous, it is distinct in many respects.

Specimens of this genus are more abundant than any other fossils in the localities in question. In two of the individuals, both xiphisternal bones are preserved; in one, the mesosternal; in two, the episternals, etc. Three species appear to be represented by my specimens, which vary from the size of the salt-marsh terrapin, *Malaclemmys palustris*, to that of the Mississippi snapper, *Macrochelys lacertina*.

NOTOMORPHA TESTUDINEA. Cope. spec. nov.

Represented by portions of four or more individuals. In one of these the anterior lobe of the plastron is in part preserved. The mesosternum is a transverse oval, the posterior margin regularly convex, the anterior with three equal borders. The median of these is concave. The sutures are radiating, and the groove separating the humeral scuta, appears to traverse the entire length of the bone. The outer surface is gently convex. The free margin of the episternal and hyposternal bones is acute, and with an internal thickening, as in *Cistudo*, *Testudo*, etc., forming a ridge, with abrupt inner face. This face extends backwards as a groove, to the axillary process of the hyosternal, forming a characteristic mark. Although the extremity of the episternal bone is lost, and the mesosternal exhibits no trace of the intergular scute, the outer sutures of the gular scuta are so far posterior, as to render it highly probable that the intergular plate existed. At the point where this suture reaches the margin, the latter is openly emarginate. The posterior suture of the humeral scute crosses the margin half way between the axilla and the episternal suture, and is not marked by a notch. The last named suture is transverse. On the xiphisternal bones the groove of the anterior suture of the anals is plainly visible. It is regularly convex forwards and in one specimen is double.

In a second specimen of about the same size, parts of two costal bones are preserved. They are thick, and display the usual costal and vertebral scute-sutures. The latter one in a groove, for the middle of the vertebrals is elevated, and the costals project shoulder-like just outside the groove.

In a third specimen a little larger, xiphisternals with several marginals are preserved. A free posterior marginal is regularly recurved, and the scute-sutures are deeply impressed. The marginal scuta have evidently been marked with concentric grooves within their margins. The first marginal bone of the bridge has a very obtuse edge.

In none of the specimens are the surfaces sculptured.

Measurements.

No. 1.	M.
Width plastron at axilla	0.086
Length plastron from axilla (approximate)	.05
Thickness hyosternal at mesosternal	.009
" " " hyposternal	.0065
Width mesosternal	.037
Length "	.026
Thickness of a vertebral	.006
" " xiphisternal (normal)	.004
" " " at pubis	.007
No. 2.	
Thickness costal at hump	.0075
Width of costal	.0175
No. 3.	
Width of posterior marginal	.027
Length " "	.019

The mesosternal, though found with No. 1, does not fit it exactly and does not belong to it.

NOTOMORPHA GRAVIS. Cope. species nova.

This species is known by portions of one, and probably of other specimens. The type is larger than any of the last described, and equalled some of the *Cheloniae* of the ocean in dimensions. The right hyosternal bone indicates both resemblance and difference from the *N. testudinea*. The former is seen in the internal thickening parallel to the margin, bounded behind by a deep groove extending to the axilla. A peculiarity, in which it differs from the *N. testudinea*, is seen in the posterior position of the humero-pectoral dermal suture, which originates at the axilla. The epi-hyosternal suture is concave. The thickened portion of the episternal margin is shorter and wider than in the species just named, the width being to the length as 2.5 to 2; in *N. testudinea*, as 1.5 to 2.

	M.
Thickness of hyosternal anteriorly	.011
Width of costal, (?) second specimen	.058

Surfaces not sculptured.

NOTOMORPHA GARMANII. Cope. spec. nova.

Represented by numerous fragments from a bluff, six miles north of the Bear River. There are numerous bones of the carapace and plastron. A characteristic piece is the episternal bone. It displays marked difference from the same element in the type of the genus, in lacking the acute edge and internal thickening. The margin is obtusely rounded and the suture with the hyosternal is convave. The anterior margin is truncate. The dermal sutural grooves are well marked. There is a large intergular scutum, which evidently encroached considerably on the mesosternal (a piece not preserved) and probably subtriangular in shape. The gulars are reduced to triangular areas on the outer anterior angles, the suture, with the humeral, being in front of the middle point between the angle and the hyosternal suture. The margin is less distinctly emarginate at this suture than in *N. testudinea.*

The marginal bones belong to both bridge and free edge. They are all much thickened medially, but with thin proximal sutural margins. The free ones are well recurved, and with regular, rather thickened margins. The bridge marginals have very obtuse margins. Their general massiveness is in contrast to the thinness of the costals of which there are numerous fragments. Portions of vertebral bones are intermediate in thickness. There is no thickening or ridge on each side of the vertebral scuta. The scutal grooves are everywhere well marked. The surface of the marginals and episternal is obsoletely rugose, somewhat as in some species of *Taphrosphys*, from the Cretaceous.

This species was about the size of *N. gravis*, and differs from it in the episternal bone, etc.

Measurements.	M.
Length of episternal (approximate)	0.04
" from posterior suture do. to gular scute	.02
Thickness episternal, behind	.011
Length of a marginal bone	.042
Width of same " "	.045
Thickness " " "	.015
Width of a bridge-marginal	.04
Thickness of a vertebral	.007

This species is dedicated to my assistant and friend, Prof. Saml. W. Garman, of Chicago, whose eye detected the fragments which teach its character.

At a future time it is hoped that a fuller account of the fauna of this lake basin, now enclosed between the Eastern and Western ranges of the Wahsatch Mountains, may be given.

ON THE TERTIARY COAL AND FOSSILS OF OSINO, NEVADA.

By Edward D. Cope.

(*Read before the American Philosophical Society, July* 19, 1872.)

The locality of the exposure of these coals is in the northeastern portion of Nevada, twenty-five miles northeast of Elko, on the Central Pacific Railroad. The outcrop is on the south side of the low mountain range, bounding Humboldt Valley on the north. The beds are exposed in a drift and adjacent cutting, and a shaft 200 feet in depth. The strata are argillaceous, and in some degree calcareous, and are very thinly laminated; so much so as to resemble thin brown or black paper in some portions of the series. They are highly carbonaceous, and burn freely; some of them with the odor of amber, which appears as a gloss on some of them. Descending sixty or more feet through these shales, we reach a bed of solid argillaceous material, of a dark green color. This can be removed with the pick, but hardens on exposure to the atmosphere. It contains fresh-water shells. The first bed of coal is two and a half feet in thickness, with one or two laminæ of slate. The second bed is twelve feet deeper, and is about three feet in thickness. In quality, both resemble cannel, but have more lustre.

Masses of the laminated shales resemble the *braun-kohle* of Bonn, Prussia, and they contain fossils disposed in the same way. These consist of multitudes of leaves, mostly of dicotyledonous plants; of molluscs, insects, and fishes; the last two often in a fine state of preservation. The molluscs present forms similar to *Planorbis*, *Vivipara*, etc. The insects are mostly Diptera, and some of them are Nematocera. The fishes are fresh-water forms, of which, perhaps, four species were procured. I have made an examination of two of these, and find them to represent both species and genera new to science. One of these is of interest, as furnishing the first evidence of the appearance of the *Catostomid* type, now so extended in North America; the other is allied to a genus which has been discovered in the Eocene shales of Green River.

The shales are considerably less indurated in general than those of Green River. They have been greatly disturbed by the elevation of the ranges bounding Humboldt Valley, as they dip nearly south, at an angle of forty-five degrees, at the mine.

The same shales are exposed in the ravines on the south side of the valley, dipping at one point where a drift has been run, at an angle of forty-five degrees to the northeast. They contain at this place plants and shells similar to those of the north range.

The descriptions of two of the species of fishes are appended, with remarks. Further investigation will, no doubt, determine the age of this series.

Extensive beds of a highly silicious amorphous rock appear near to these shales, one series being exposed in a nearly horizontal position in the valley, but little below the coal shales, and apparently occupying a higher horizon. They are filled with huge silicious concretions, and in many places assume the appearance of sandstone. Similar strata of sil-

icious rock cap the foot-hills of the range, forming their southern slopes with the southern dip, appearing to be nearly conformable to the shales. Their escarpments are to the northward, and the outcrops are fissured in every direction, the debris being scattered over the lower levels. On one of these rather elevated valleys I found abundant remains of the trunks of ancient forest trees, completely silicified. Many of the trunks must have measured five feet in diameter, and display the concentric laminæ of the dicotyledonous type. They were variously altered; some becoming chalcedony, and others opal; portions being black, red, yellow, purple, or white, of great purity.

At another outcrop of the silicious strata, a few miles distant from the above locality, the rock was found to be variegated by concentric bands of red, yellow, black, and white. Though fine in texture, it is not sufficiently translucent to constitute a valuable agate, which it otherwise resembles.

The connection between these silicious strata and the silicified wood seems apparent. The silica deposited in sufficient quantities to form strata of from twenty to forty feet in thickness, would suffice to impregnate submerged forests. That these strata are of sedimentary age is not settled, but they seem to be conformable to, and later than the tertiary shales just described.

TRICHOPHANES. Cope. Gen. nov.

Allied to *Erismatopterus*, Cope, and to the family of *Cyprinodontidæ*. Dorsal and anal fins short, each with a long and short spinous ray on the anterior margin. Ventrals beneath the dorsal. Operculum, with a longitudinal keel above. Mouth with wide gape, extending beyond orbit. Scales wanting, represented by rigid fringes or hair-like bodies.

Several important characters of this genus are not very distinctly displayed by the specimen described. This is especially the case with the maxillary region. The premaxillary bone evidently forms a large part of the arcade of the mouth, but whether the whole, is not certain. The presence of teeth, and number of branchiostegal radii, cannot be stated.

Other points, more definitely exhibited, are a preoperculum without serrations, directed a little obliquely backwards; a coracoid of little width; an inferior postclavicle with a superior (proximal) conchoidal expansion and long, slender shaft, extending to the anterior extremity of the femora. The latter are quite slender and acuminate anteriorly, and grooved to the apex, but apparently not furcate. They do not present any marked posterior union. Vertebræ not elongate.

Caudal fin furcate. Interneural spines wanting in front of dorsal fin; those of the anterior rays very strong. Interhæmals of the anterior anal rays similarly strong. Caudal fin embracing one vertebra, and supported by separated hæmal spines.

The characters which separate *Trichophanes* from *Erismatopterus*, are seen in the large mouth and short muzzle, and in the peculiar covering of the body. In the former character it resembles some of the *Scopeli*,

while the latter is not seen in any genus. The bristle-like bodies are scattered over the whole extent of the fish, excepting the head and the fins, and are arranged in little aggregations, which are irregularly disposed. The processes themselves lie irregularly together, as though free from each other, and are evidently not the impressions of keels of the scales. Traces of other scales are not visible, and the bodies described would suggest the existence of an ossified ctenoid fringe on a less fully calcified scale, or possibly without such basis.

TRICHOPHANES HIANS. Cope. Sp. nov.

Vertebræ, D. 9; C. 15; six between interneural spine of dorsal, and interhæmal of anal fin. Radii, D. II. (?) 6 (soft rays somewhat injured); A. II. 7; V. and P. not all preserved; caudal rays numerous, forming a deeply bifurcate fin. The ventrals reach a little over half way to the anal, and the latter about half way from its basis to that of the caudal fin. The dorsal fin, laid backwards, reaches the line of the base of the first anal ray. The first dorsal ray is a little nearer the end of the muzzle than the origin of the caudal fin. The muzzle is very obtuse, and if the specimen be not distorted, not longer than the diameter of the orbit. The gape extends at least to the posterior line of the orbit. The suborbital region deep posteriorly.

In its present somewhat distorted condition the specimen measures in

	M.
Total length	0.059
Head	.016
Vertebræ	.029
Caudal fin	.0142
Length dorsal spine	.008
" anal	.008
" of hair-like bodies	.0005

AMYZON. Cope. Genus novum Catostomidarum.

Allied to *Bubalichthys*. Dorsal fin elongate, with a few fulcral spines in front, and the anterior jointed rays osseous for a considerable part of the length. A few short osseous rays at front of anal fin. Scales cycloid. Caudal fin emarginate. Mouth rather large, terminal.

The characters of this genus appear to be those of the *Catostomidæ*. There are three broad branchiostegals. The vertebræ are short, and the hæmal spines of the caudal fin are distinct and rather narrow. In one specimen a pharyngeal bone is completely preserved. Not having it before me at the moment, I merely observe that it is slender, and with elongate inferior limb. The teeth are arranged comb-like, are truncate, and number about thirty to forty. This and other portions of the structure will be more fully described when the whole series of specimens is investigated. The bones bordering the mouth above are a little displaced, and the lower jaw projects beyond them, and is directed obliquely upwards. The dentary bone is slender and toothless, and the angular is

distinct. The premaxillary appears to extend beneath the whole length of the maxillary. Should this feature be substantiated, it will indicate a resemblance to Cyprinidæ. The maxillary has a high expansion of its superior margin, and then contracts towards its extremity. Above it two bones descend steeply from above, which may be out of position. The preoperculum is not serrate. The superior ribs are well developed.

This form approaches, in its anterior mouth, the true Cyprinidæ through *Bubalichthys*. It is the first extinct form of Catostomidæ found in this country.

AMYZON MENTALE. Cope. Species nova.

This fish occurs in considerable numbers in the Osino shales, and numerous specimens have been procured. Two only of these are before me at present. They are of nearly similar length, viz., M. O. .12 and .105. The most elevated portion of the dorsal outline is immediately in front of the dorsal fin. From this point the body contracts regularly to the caudal fin. The dorsal fin is long, and is elevated in front and concave in outline, the last rays being quite short. They terminate one half the length of the fin in front of the caudal fin. The interneural spines are stout in front and weak behind. Radii, III. 26, and (?) II. 23. There are about twenty-three vertebræ between the first interneural spine and the end of the series in the former specimen, in which, also, there are no distinct remains of scales. In the second, scales are preserved, but no trace of lateral line; there are six or seven longitudinal rows above the vertebral column. The anal fin is preserved somewhat damaged; the rays are not very long, and number II. 7. The anterior interhæmal is expanded into a keel anteriorly. Ventral fins injured.

The ribs and supplementaries are well developed. The inferior quadrate is a broad bone, with deep emargination for the symplectic. Depth No. 2 in front of dorsal fin, M .025. Length basis of dorsal, .026.

ON THE EXISTENCE OF DINOSAURIA IN THE TRANSITION BEDS OF WYOMING.

BY EDWARD D. COPE.

20th Sep/72

(*Read before the American Philosophical Society, Sept.* 19, 1872.)

During the present season, F. B. Meek, of Dr. F. V. Hayden's Geological Survey of the Territories, discovered some large bones near Black Buttes Station, on the Union Pacific Railroad, fifty-two miles east of Green River, and near the Hallville Coal Mines. Shortly afterwards I visited the spot with a branch expedition, and commenced excavations with a view to the recovery of the remainder of the animal. The position was discovered to be between the thinner or lower strata of the Bitter Creek series of coal, which at this point, occupy a position of elevation and crop out high on the bluffs. Two strata appear above the

sandstone in which the bones occur, and one below it. The portions of the skeleton found, rested in the midst of vegetable debris, as sticks and stems, and was covered with many beautiful dicotyledonous leaves, which filled the interstices between the bones. The plant-bed gradually passed into a shell-bed, containing numerous thin dimyaria, and close by, some oysters were found. The whole question as to geologic age and aqueous conditions during which these beds were deposited, being unsettled, I gave especial attention to the recovery of the bones, with the view of reaching a definite conclusion on these points.

We succeeded in recovering sixteen vertebræ, including a perfect sacrum, with dorsals and caudals; both iliac and other pelvic bones, those of one side nearly perfect; some bones of the limbs, ribs and other parts not determined.

The vertebræ are large. The dorsals are short, with vertically oval centra, and small neural canal. The diapophyses originate well above the neural canal, diverge upwards, and are triangular in section. The neural spine is very much elevated, and the arch short antero-posteriorly. The zygapophyses are close together in both directions, those of the same aspect being separated by a narrow keel only. They no not project, but consist of articular surfaces cut into the solid spine. The latter is flat and dilated distally. The articular faces are nearly plane with a slight median prominence.

The ribs have two articular surfaces, but I found no capitular pit on the dorsal centra.

Elevation of centrum, 7.5 in.; width of the same, 5 in. 7.5 lines; length of do. 3 in. 8.5 lines. Total elevation of a dorsal vertebra, twenty-eight inches three lines. The sacrum consists of five vertebræ, the anterior centrum not depressed. They give out huge diapophyses which are united by suture. They are themselves united distally in pairs, each pair supporting a longitudinal convex articular face for the ilium. Each pair encloses a perforation with the centra. The first diapophysis goes off from the point of junction of the first and second vertebræ, the second from the third only, and is more slender. The total length is 25 in.; and the width 30 in. Its vertebræ are flat below, with latero-inferior angles. The last centrum gives off a simple diapophysis.

Another vertebra exhibits a diapophysis as low as the floor of the neural canal and united by coarse suture. Others posterior to the sacrum are more elongate with slightly compressed centrum, and with diapophysis opposite floor of canal and not united by suture. Centra flat below; no chevron bones discoverable. Length centrum, 4 in. 4 lines; depth of articular face, 4 in.; width of do. 4 in. 3 lines.

The iliac bone is extended antero-posteriorly. One extremity is thick and rather obtuse, but of little depth. There is a large protuberance above the acetabular sinus. The other extremity is dilated into a flat thin plate of rather greater length than the stouter extremity. From

one of its margins, a rod-like element projects. Its total length is about four feet, of which the acetabular sinus measures about 8.10 inches.

A short bone pertaining to the limbs has the articular surfaces at a strong angle to each other, hence the shaft is twisted. It is deeply grooved on one side near the extremity. The other extremity bears a rather flattened hour-glass shaped articular face, and below it on one angle is a crest. The convexity of the surface is not great, and this extremity resembles that of a Dinosaurian or Crocodilian reptile. Its length is, however, only eight and a quarter inches; apparently too small for a humerus, though this is not certain, while it is decidedly too small for a metatarsal of such an animal.

From the above description, it is evident that the animal of Black Buttes is a Dinosauran reptile, the characters of the sacral and iliac bones alone sufficing to demonstrate this point. If the reader will compare the measurements given for species of this group already known, he will observe that those of the present animal exceed those yet described from North America. It is possible that if the corresponding parts of *Hadrosaurus tripos*, Cope, or *Thespesius occidentalis*, Leidy, are discovered, they may approach it.

It is thus conclusively proven that the coal strata of the Bitter Creek Basin of Wyoming Territory, which embraces the greater area yet discovered, were deposited during the Cretaceous period, and not during the Tertiary, though not long preceding the latter. It appears that the forests that intervened between the swamps of epochs, during which the coal was formed, were inhabited by these huge monsters. That one of them laid down to die near the shore of probably a brackish-water inlet, and was soon covered by the thickly fallen leaves of the wood. That continued subsidence of the level submerged the bones, which were then covered by sand.

The form of the ilium differs very materially from that of *Hadrosaurus*, and the vertebræ are plane, thus differing from *Thespesius*. The limb bone is distinct from anything in *Lælaps*, which, moreover, probably resembles *Thegalosaurus* in its ilium. The present form recalls rather *Cetiosaurus*. As it is evidently new to our system, it may be called Agathaumas sylvestris.

NOTICES OF NEW VERTEBRATA FROM THE UPPER WATERS OF BITTER CREEK, WYOMING TERRITORY.

By Edward D. Cope.

20th Sep p.515

(Read before the American Philosophical Society, September 19, 1872.)

Synoplotherium canius. Cope. Gen. et sp. nov.

This genus possesses the dental formula so far as known, I.$\frac{3}{1}$c.$\frac{1}{0}$M.$\frac{7}{5}$. In the only specimen with molars, the crowns are much worn, but in all, the antero-posterior much exceeds the transverse diameter, and consisted

of two lobes. The posterior molar had no more lobes, and is smaller than the penultimate. The first is two-rooted, and is separated by a wide space from the inferior canine. The superior canine is of disproportionately large size, and issues a little behind the premaxillary suture. The incisions are crowded closely together, and are of conic form. The exterior is several times as large as the others. The inferior incisors are of huge size, project upwards after the manner of rodents, and are inserted by a short base into the solid symphysis. They are separated by a short interspace, which is without alveoli.

The fore foot possesses four digits, of which the inner is considerably the shorter. Phalanges not slender; ungueals flat, deeply fissured above. Caudal vertebræ slender.

This most remarkable genus is not at present referable to its proper order. The superior anterior teeth are of carnivorous type; the opposing teeth look like those of rodents, while the molar teeth differ from both. It is allied to *Anchippodus*, Leidy, which is only known from mandibles. This form Dr. Leidy has called the "gnawing hog," but, as it probably exhibits a structure similar to that seen in the present genus, it is obvious that the huge symphyseal teeth were not designed for gnawing in the usual sense. I suspect these animals to have lived largely on turtles,* and that the structure in question was adapted for crushing their shells. This is the more likely from the prodigious number of turtles which must have existed contemporaneously with them. There are twenty species described from the Bridger formation, and their numbers are legion, as already described by Professor Marsh. Their bones are always in sight, and six or eight are not unfrequently found lying together.

Char. specif. The mandibular rami, posterior to the symphysis, are not heavily constructed. The symphyseal teeth are very stout, and exhibit two longitudinal grooves on the outer and outer inferior face; the shaft is compressed, and the worn surface is on the outer side, as produced by the canines, and on the extremity, produced by the outer incisor. The superior canine is compressed, and as large as that of a grizzly bear. The outer incisor is nearly straight, and with conic crown. A large part of its shaft is exposed at the bottom of a wide vertical groove, which extends upwards between the canine tooth and a ridge descending from the edge of the nares. The external nareal opening is entirely anterior, and is narrowed below, in accordance with the narrowing of the premaxillaries.

	M.
Length of interior dental series to bases of symphyseal tooth	0.170
Depth ramus at last molar	.050
Length symphysis	.060
" muzzle from canine	.017
Length symphyseal tooth projected	.010
Diameter " " "	.026
" canine " "	.023

* This view was already expressed in *The Friend*, Philada., 1872, Winter

If the body of this animal were of usual proportions as relates to the skull, it was about the size of the black bear (*Ursus americanus*). The worn condition of the teeth indicates an old animal, and one that had lived on hard food.

EOBASILEUS CORNUTUS. Cope.

Gen. et sp. nov.

Established on remains of five individuals of the average size of the *Mastodon ohioticus*. These indicate clearly a form of proboscidian not before recognized. The structure of the tibia and astragalus, clearly indicate that the species is not artiodactyle, while the perfectly simple femur is not perissodactyle. The posterior part of the cranium, and the short stout phalanges are proboscidian. The existence of horns on the frontal bones separates it at once from *Dinotherium*, *Mastodon*, *Stegodon*, or *Elephas*, and indicates a remarkable combination of structure not before known to naturalists. The gigantic size of the typical species adds to its interest, and shows it to have been the monarch of the remarkable fauna disclosed by recent researches in Wyoming.

The distal extremities of both humerus and femur are flat, the former with oblique trochlear face and shallow olecranar fossa. The great trochanter of the femur is flat and not recurved; little trochanter wanting. Spine of tibia very obtuse; distal extremity little excavated. Distal extremity of phalanges not divided by trochlear ridge.

Articular extremities of vertebræ plane; the cervicals very short.

Cranium with vertical occiput with broad convex superior outline. Temporal fossæ lateral, posteriorly small. Horn-cores obtuse, compressed, most at base; direction divergent.

NUMBER 1.	M.
Length of horn-cores (6 inches)	0.152
Elevation occiput from foramen magnum	.180
Width across supra-occipital crest	.315
" of condyles with foramen	.206
" " paramastoid process	.087
NUMBER 2.	
Transverse diameter condyles humerus	.185
NUMBER 3.	
Diameter extremity tibia (transverse)	.126
" " " (antero-posterior)	.096
" head " (transverse)	.140
" glenoid cavity scapula	.150

Further details of the structure of this animal will be sought for with interest. From the manner of its occurrence, it probably went in families or herds.

CROCODILUS CLAVIS. Cope.

This is a large species with a muzzle of narrowed proportions and sufficient depth to give it a broad oval section. The nasal bones appear to have reached the nareal orifice. The anterior superior teeth are very large, especially the canine. The inferior tooth corresponding is large,

and occupies an emargination which approaches near to the nasal suture. The pitting of the muzzle is fine, and the swollen interspaces much the wider. The teeth have stout conic crowns, with well-developed cutting edges and coarse striate sculpture. The mandible is acuminate to the narrow extremity, and has a long symphysis, which extends to opposite the third tooth behind the notch. The cervical vertebræ preserved, have round cups; they have a simple elongate hypapophysis with a pit behind it; shoulder very prominent.

	M.
Length of ramus with teeth	
" " symphysis	.135
Width do. at end of symphysis	.085
" do. " mandible	.020
" maxillary at third tooth above	.060
" " " notch above	.020

This species has a more slender muzzle than those described by Marsh and Leidy, and is of larger size.

RHINEASTES PELTATUS. Cope.

Gen. et sp. nov. Nematognathorum.

Established on cranial and other bones, with spines of a siluriform fish of the size of the largest species of *Amiurus*. The form, in the excessive rugosity of the external long surfaces, reminds one of some of the Brazilian *Dorades*. The frontal fontanelle is closed, though very distinctly marked by a groove of the surface not rugose. The rugosity consists of innumerable, packed osseous papillæ. The cranial ossification is continued posteriorly as a shield, which is strongly convex from side to side. The spine is symmetrical, and probably dorsal. It is compressed and curved antero-posteriorly, and is deeply grooved behind. Laterally it is closely striate grooved; the anterior face is narrowed, obtuse, and minutely serrate with cross ridges; each side of it is rugose with several irregular series of pronounced tubercles, arranged transversely.

	M.
Width frontal bone near front of fontanelle	0.012
Thickness at do.	.004
" " of casque	.004
Width spine	.005
Depth "	.009

RHINEASTES SMITHII. Cope.

Indicated by a dorsal spine of an individual of smaller size than the type of the last named. It is less rugose, and more firmly striate, and possesses a row of short reverted spines in its posterior groove. The anterior edge is furnished with a finely serrate keel, which has a groove on each side at the base. The section is oval, the posterior face not being flattened as in the last species. Antero-posterior diameter near middle M. .005; at base .006; width behind above base .006.

Named for my respected friend, Daniel B. Smith, of Germantown; many years Principal of Haverford College, and a student and lover of the Natural Sciences.

SECOND NOTICE OF EXTINCT VERTEBRATES FROM BITTER CREEK, WYOMING.

By Edward D. Cope. 20 th Sep. 515

(*Read before the American Philosophical Society, Sept. 20, 1872.*)

Palæosyops vallidens. Cope. Sp. nov.

Represented by the dentition of one maxillary bone with other bones of one individual; a portion of the same dentition of a second; with both rami of the mandible with complete dentition of a third. The species is distinguished by the details of the dental structure, and by the superior size. It exceeds, in this respect, the *Palæosyops major*, Leidy; while the three posterior lower molars measure 4.5 inches in length, the same teeth of the present animal measure 5.25 inches. The last superior molar of another specimen measures 2 inches in length; in the third the first true molar is 1.5 inch in length, while the last inferior molar is 2.25 inches long. The peculiarity in the structure of the superior molars consists in the existence of two strong transverse ridges, which connect the inner tubercle with the outer crescents, enclosing a pit between them. These are most marked on the premolars, where also is found the peculiarity of the almost entire fusion of the outer crescents into a single ridge. These united crescents are narrower than in *P. major*, and the summits of all the crescents are relatively more elevated. The number of inner tubercles is the same as in that species; all the teeth have very strong basal cingula, which rise up on the inner tubercle. The last inferior molar is relatively narrower than in *P. major*, and the posterior tubercle is larger and longer, and is an elevated cone.

This species is, after those next described, the largest mammal of the Wyoming Eocene.

Loxolophodon. Cope.

(Proceed. Amer. Philos. Soc., Feb. 16, 1872.)

The discovery of the remains of numerous animals of this genus, confirm the propriety of its separation from *Bathmodon*. The characters are as follows:

Type of extremities Proboscidian. Femur without third trochanter, toes short, stout. Dentition: I. 1; C. 0; P. M. 4; M. 2. The premaxillary is at the posterior margin of that bone, and is a large recurved trenchant tusk. There is a long edentulous interval between it and the first premolar, which is smaller than the others. These support an outer crescent and a small inner tubercle. In the anterior premolars, the crescent is nearly straight, in the posterior more curved. With use, the crescent and tubercle wear together and form a short lance-head surface. The crescent is angular, and occupies the whole crown in the molars, and the tubercle is small and not symmetrically placed. The teeth on the maxillary bone are remarkably small for the size of the animal. Lower jaw not observed.

The cranium presents a remarkable appearance on account of the pro-

longation of the muzzle. In front of the zygomatic arches, the form is compressed and roof-like above. Above the tusks the nasals expand, and are produced to a great distance, terminating in osseous prominences. The premaxillaries are also much produced ; their anterior part is slender and toothless, and does not extend so far as the nasals.

The orbit is not inclosed behind, and has no marked superciliary or other margin. Above it, on each side, a horn-core is given off, the pair diverging from approximated bases. Occiput vertical.

The affinities of this genus are not close to any known, excepting *Bathmodon*. This has the six premaxillaries of usual proportions, at least three true molars, and the posterior premolars with three crescents. The general relationships are proboscidian, and associated in some measure with *Synoplotherium*, *Auchippodus* and *Pseudotomus*.

Besides the *L. semicinctus*, Cope, originally described, the researches under Prof. Hayden's Geological Survey, have determined the existence of two or three other species of much larger size.

LOXOLOPHODON CORNUTUS. Cope.

Eobasilus cornutus. Cope.

Established on portions of several skeletons, including one with femur, pelvis, scapula, vertebræ and cranium. The latter measures about thirty-four inches in length. The horn-cores are very stout and sub-triangular in section at base and with a rudimental knob on the inner side ; height seven inches about. A massive protuberance of a recurved lobate outline rises on the anterior margins of the nasal bones on each side. They meet, leaving an emargination in front, giving the nasal bones a bi-lobed outline. The iliac bones are very wide, the expanse of both together being fifty-four inches. The centrum of a sacral vertebra is four inches in diameter.

LOXOLOPHODON FURCATUS. Cope.

This species is indicated by portions of the nasal bones. These have differed in form materially from those of the *L. cornutus*. The convex protuberances seen in *L. cornutus* were here represented by processes of singular form. They were compressed, narrowed at the base, and expanded distally into a flat spatulate body. The whole process measures seven to eight inches in length, and three and a-half in width distally. The animal could not have been materially smaller than the *L. cornutus*.

LOXOLOPHODON PRESSICORNIS. Cope.

Established on numerous remains, including horn-cores of species similar in size to the last. Its marked peculiarity, as first noticed, consists in the compression of the horn-cores throughout the proximal half of their length, with their more acuminate form, than in *L. cornutus*. They measure also about seven inches in length.

The affinities of these remarkable animals will be shortly discussed.

They were the gigantic mammals of our Eocene period, representing the Elephants and Mastodons of the Miocene, which they equalled in size.

The Geological Structure of Tazewell, Russell and Wise Counties, in Virginia.

By. J. P. Lesley.

(Read before the American Philosophical Society, April 21st, 1871.)

I was called upon recently to examine a part of the Alleghany Mountain Range, between the New River (Kanawha) in Middle Virginia and the north line of the State of Tennessee, for the purpose of determining the nearest possible approach to a workable coal region of a contemplated Railway from Harper's Ferry on the Potomac to Knoxville in Tennessee.

The geological structure of this part of the United States is so peculiar and so nearly unknown to geologists, or at least unnoticed in any published memoirs, that I have taken some pains to portray it, believing that it will be an acceptable contribution to the literature of the science and to the proceedings of this Society. The present paper is, however, a virtual continuation of my description of the South Virginia Coal region of Montgomery and Wythe Counties, read before this Society in 1862, and published in Vol. IX of its Proceedings, pages 30 to 38.

Professor William B. Rogers, State Geologist of Virginia, is well acquainted, no doubt, with the essential facts about to be described, and probably has materials for a more extensive description of the central belt of the Appalachians among the unpublished archives of the State Geological Survey of Virginia; but I doubt that any sections have been constructed which express more clearly the state of things in a geological sense, than those which I have this opportunity of making known.

Professor James M. Safford, State Geologist of Tennessee, has studied the Southern continuation of the belt, and describes it in his Geology of Tennessee, Nashville, 1869. But the sections given in that valuable work, which has cost its author so much time, skill and labor to prepare, and for which American Geologists are most grateful, are only adapted for general description, not being drawn to a natural scale, and are not of use for the critical study of the dynamic problem here offered to the consideration of structural geologists.

The map which accompanies this paper was made to show the railway avenues through the region above named, by bringing out clearly its main *topographical* features. I have colored it to show to the eye its main *geological* features, especially those due to the lines of Downthrow, which are also the lines of limit for the Coal Measures. I have confined the coloring within narrow limits so as not to obscure the prime facts. No distinction is made therefore between the Calciferous, Trenton, Birdseye, Black River and Hudson River formations, all of them being colored

blue, representing the *limestone valley formations*, Lower Silurian, Nos. II and III of the Pennsylvania nomenclature.

The Oneida Conglomerate, Shawngunk Grit, and Medina Sandstone, Middle Silurian, No. IV, are left uncolored, to make their mountain character more conspicuous. The Upper Silurian, Clinton, No. V, carrying the Dyestone, Fossil Iron Ore, is colored red, to catch the eye, because of its practical importance for railway purposes, and because it is the red formation of the North, *par excellence*, although it is not so marked in nature along its southern outcrops. If the native coloring of the soil were to govern the tinting of the map the Hudson River slates (No. III) would require this pigment.

The Devonians are represented by a Vandyke brown wash (Nos. VIII, IX, X), and the Coal Measures by a wash of Payne's gray. No color is allowed for No. XI., which shows so prominently on the geological map of Pennsylvania in red, because its outcrop is feeble here and *not* especially red.

The main features of the topography are quite correct (except near its eastern end, of which I can say nothing); and it distinctly shows how the mountains are made, by the downthrows, to run in pairs, with a "poor valley" between each pair, consisting of Devonian Sandstones and Upper Silurian shales containing the Clinton, Dyestone, or Fossil Iron Ore; and how the pairs are separated by wider Lower Silurian limestone or "rich" valleys, containing the villages and farms of blue grass and scattered and probably extensive deposits of Brown Hematite Iron Ore, which I have *not* colored.

The black lines 1, 2, 3, 4, &c., show where the vertical geological sections in this report are to be looked for on the map.

There is no map of this country worthy of the name. I have copied the State map and then changed its details according to my observations. The geology is perfectly simple, when one has the key to it. The key to it is given by the pairing off of the mountains along the Downthrows.

I begin then with this curious and all important phenomenon. Fig. 1, shows it in a *purely ideal* way; but reference must be made to Sections 1, 2, 3, 4, &c., for its *actual* representation in different places.

Fig 1.

IDEAL CROSS SECTION, SHOWING THE CRACKS OR DOWNTHROWS.

What the power was, which cracked the anticlinal and synclinal curves,

and shoved the 10,000 feet of Carboniferous, Devonian, and Silurian Formations over each other, like cakes of ice in a river freshet, it would be premature here to discuss.

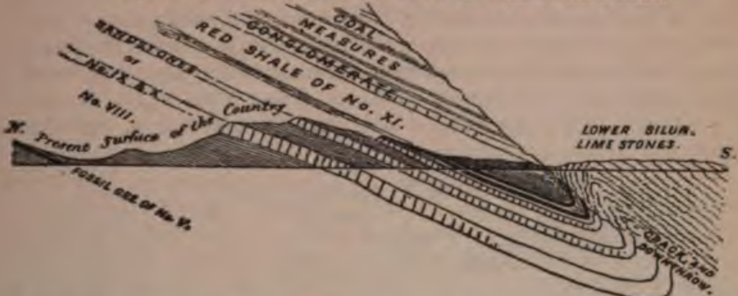
The consequence has been, that along the straight lines of these cracks —lines running for fifty or a hundred miles,—the coals at the top of the system abut against the limestones near its bottom.

Another consequence has been that no coal is to be found but on the north side of each crack. The whole mass of rocks above the line A—B has been removed (it is needless to describe the process, which is still going on and can be studied by any observer), so that the vast coal field which once covered this country is no longer in existence; and the only remnants of it left are long stripes, a few hundred *yards* wide, running along the north lip of each crack.

A third, and equally important consequence, has been, that even this poor remnant of the Coal-Measures, where it is left, consists of only the very lowest bed or the two lowest beds of the Coal Measures, the poorest of all the coal beds of the system. Fig. 2 will show how this result occurs:

Fig. 2.

SHOWING THE COAL BEDS LEFT IN THE DOWNTHROW



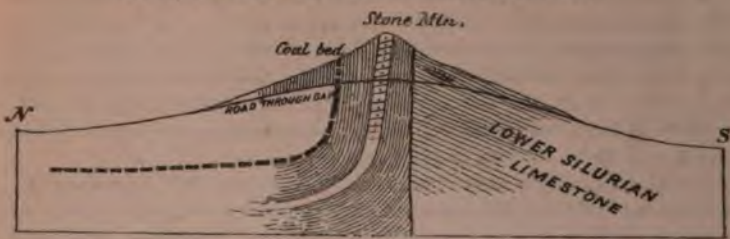
It is not until, going north 30° west, several such downthrows with their comparatively worthless coal fields (so to call them) have been passed, that the real coal field of the country is reached. Its southern edge runs along a straight downthrow lying just north of the Clinch River.

I shall first take up this line at Guest's River, in Wise County, and follow it northeastward, ascending Clinch River; and I will give sections of its Coal Measures, wherever I studied them.

Stone Mountain, which is the south border of the Guest River Coal Fields, in Wise County, is cut throughby Powell's River at the Big Gap] Some miles further east its summit is notched by a wind-gap (Little Gap), through which the turnpike from Wise County Court House (Gladesville) to Scott County Court House (Estillville) passes. The *lowest coal bed* is opened on the side of the road a quarter of a mile before

reaching the gap ; that is, high up the southern face of the mountain. The coal bed is 4 feet thick, and vertical. The core of the mountain is a vertical Conglomerate Sandrock. On the south face of the mountain are cliffs of Lower Silurian limestone. A fault, therefore, runs through the mountain lengthwise, thus :

No. 1 SECTION LINE ON THE MAP.



This section, however, I did not myself see ; but the information from which I construct it was given to me so clearly, and agrees so exactly with what I saw myself further east, that I have no hesitation in assigning it a place in this report, without endorsing it more specially.

On the west side of Guest River, two miles below the mouth of Tom's Creek, a *two-foot coal bed* is mined ; it lies nearly flat, under cliffs of horizontal conglomerate rock. Below this place, the river enters the cañon, through which it rushes for two miles before entering the Clinch River. Vertical walls of conglomerate, hundreds of feet high, stand opposite each other. This is the natural gate for a railway line to the Wise County and Kentucky Coal Field.

SECTION 2 ON THE MAP.

Coal beds are opened up and down Tom's Creek and its branches. One coal bed, from 5 to 6 feet thick, runs through the bases of all the hills, nearly at water level, and almost horizontal. It is mined for family use in the gulches back of Guest's Station (an old log fort, now a store and, although half a mile from the mouth of Tom's Creek, overflowed whenever Guest River is in high freshet), and by Mr. Jessee, and for several miles still higher up Tom's Creek. It is mined up Little Tom's Creek, and on Crab Orchard Creek, as a fine six (6) foot bed of rather handsome flaming coal, solid enough to wagon over rough roads, and not making much ashes or clinker in the grate. It is at least equal to

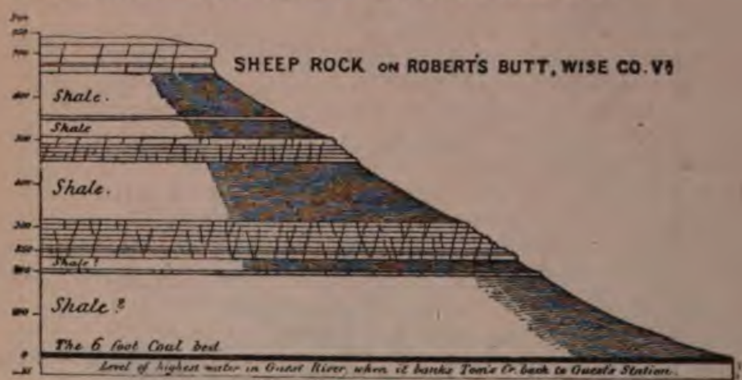
SKETCH OF ROBERT'S BUTT.

The Great Sheep Rock on Robert's Butt

the general run of the Lower Coal Measure coals in the Bituminous Coal Basins of the Susquehanna West Branch and the Conemaugh. I saw no other beds here; but there must be others both below it and above it; for the beforementioned two-foot bed ought to be above it, as the above section (2) shows.

I made a measured section of one of these hills, called Robert's Butt (over 700 feet high, and capped with a fragment of the great conglomerate sandrock which once covered all the country), as a specimen of the barriers which separate all these streams from one another, in the coal field, and to show how impracticable any railroad line must be which does not follow closely the great water-courses.

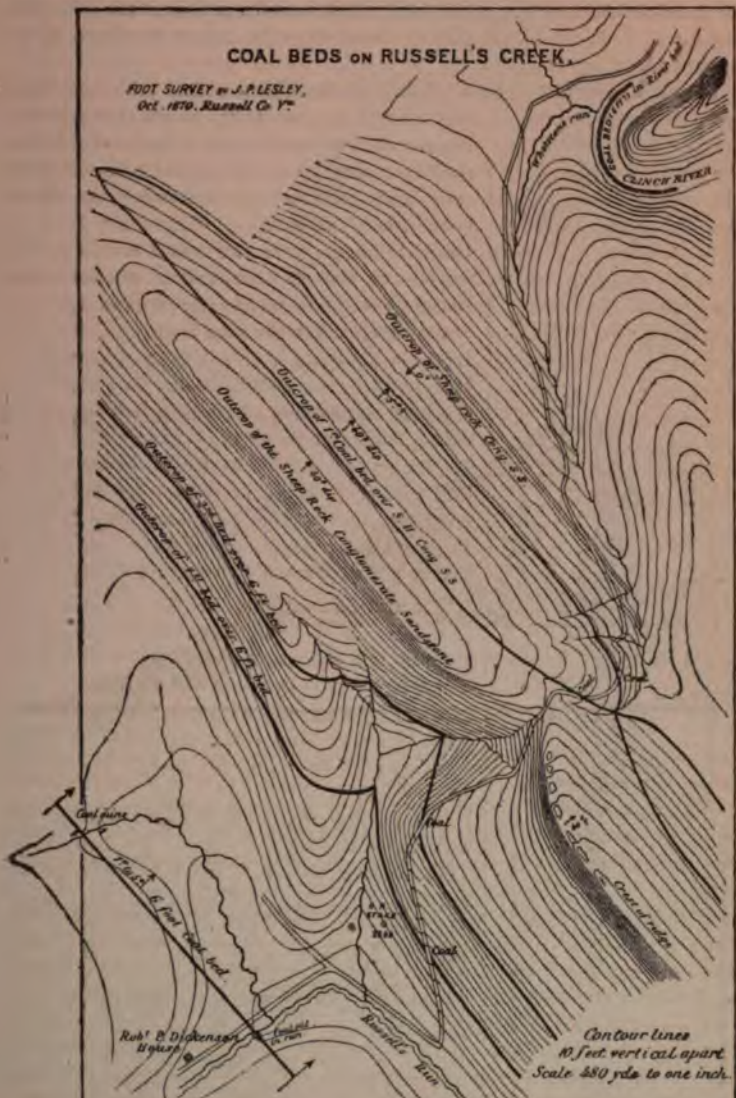
The following section up the side of Robert's Butt, half a mile north of Guest's Station, was made with an aneroid barometer. It shows the Sheep Rock Conglomerate Sandstone to be about 700 feet above the (Newberry, Robinet, Grier, Jessee, &c.) Six-Foot Coal Bed :



At one place where the bed has been dug a little into, it yields the best kind of bituminous coal, fat and caking, but friable, with no appearance of sulphur, and making no clinker. It is good blacksmith-coal, and no doubt will make good coke. A piece of ill-made coke from what is, perhaps, the same bed, near Gladesville, shows that the best coke can be got from it.

On *Russe's Creek* this coal bed is also at water level and has been mined by Robert P. Dickenson in the bed of the creek, near his house, and in a run a quarter of a mile further east, where a horizontal gangway has been commenced. About 5 feet of the coal is visible; the bottom is not reached, being in water. Roof: a shaley clay, without distinct plant impressions. Upper part of the bed bituminous, and somewhat bony. From the first 12 inches downwards, solid, and somewhat like cannel. Coal in some parts slightly granular, reminding one of the sand-coal of Montgomery County. Bottom coal very good for blacksmithing; makes a hollow fire; but cakes little and goes out before morning; not much ashes; ashes white; makes a yellow blaze; no sulphuret of iron visible; no fossil leaves. Streaks of coal through the bed showing

numerous minute discs of sulphuret of iron in the fissures; so that an analysis of the bed as a whole will give a notable percentage of sul-



phur; and it will be extremely difficult to pick the coal, if mined extensively, so as to furnish it free of sulphur. It is, however, on the whole, a satisfactory bed; and its harder benches will bear carriage well.

The bed dips at least 5° southward at this precise place; but not so much over a larger area. Over it are thin slabs of shaley sandstone, with large calamites and stigmaria stem impressions; and over these again a small coal bed; which cannot lie more than 20 feet, if that, above the other bed.

I made a careful survey of the hill to the south of this place, the summit of which is made by south-dipping conglomerate sandrocks (Sheep Rock of the last section); and found two coal beds outcropping on its north face, and two more on its south face, descending Whetstone Run to Clinch River. This run has a conglomerate terrace on its left bank, and is rendered very rocky by the descent of fragments of rock.

No. 3 SECTION ON THE MAP. RUSSELL'S CREEK.

Section No. 3 on the map is the most instructive I could obtain in this district of the region, and requires no explanation. It shows that the distance from the Six-Foot Bed up to the Sheep Rock Conglomerate is everywhere about 700 feet, and contains at least two coal beds; and that there is one more coal bed above the conglomerate. I had no means of determining the size or quality of any one of these three beds; but they are all, probably, under 3 feet.

The above sketch-map and this accompanying cross-section (No. 3) were measured on the ground and drawn to scale. They enable me to speak of only *one* coal bed above the Sheep Rock Conglomerate, with two outcrops on this road, looking like two coal beds. Further east, as will be seen, this bed (?) has several others over it.

The section renders it doubtful whether the coal dug at lowest water in the bed of the Clinch at the mouth of the Whetstone be the six-foot bed. It looks more like the second bed above it. But the southeast end of the section is a little obscure, and I had no time to study the exact character of the Downthrow of the Coal Measures against the limestones* at this point. It runs through an isolated hill, quite surrounded by a bend of the river, as shown in the sketch-map on the next page.

* Query.—Do these belong to an outcrop of the subcarboniferous limestone issuing from the fault?

The map below will give a better idea than any verbal description of the difficult nature of the ground for railroading purposes down Clinch Valley. The hills are from 200 to 300 feet high and present bold and massive cliffs of Lower Silurian limestone to the river.

It will also illustrate the general law that the principal rivers and large streams of this region of Virginia run in the lower members of the Lower Silurian limestone system, as they habitually do elsewhere, near the edge of the Freestone Carboniferous land. The cause of this is evident. The surface of the country as it is at present has been produced by the removal of all the geological formations above that which now forms the surface. When the Downthrows were first formed the drainage of the

SKETCH MAP OF CLINCH RIVER,
where it strikes the Coal Measures and rebounds, at Lick Run.

country was down the face of the Coal Measures to the crack and then along the crack sideways. This produced a very slow erosion of the Coal Measures, because of their numerous massive bed of sandstone. But the drainage along the cracks produced great erosion into the face of the sandy and magnesian limestone exposed by it. The drainage from above also produced caverns in the limestone. Out of these caverns issued streams which swelled the rivers which ran along the cracks. The formations over the limestone were worn rapidly away. The face of the limestone wall of the crack was worn back. And so, by the time the present surface level was reached, the rivers, which originally flowed on the Coal Measure side of the cracks, had got their valley-beds fairly established on the limestone side of the cracks; and, sometimes, at a considerable distance on that side.

As the lower limestones are massive and very soluble all the streams of the region which flow through them have extremely rough and tortu-

ous valleys, walled in at intervals with cliffs. The smaller streams head up in smooth valleys (of the upper limestones and slates of the Lower Silurian system) admirably fitted for railroad locations. But near their mouths, where they cut rapidly down through the lower limestones to flow into the cross streams, their beds are full of jagged rocks and their valleys difficult for cheap railroading.

It is among these lower limestones that the beds of *brown hematic iron ore* lie. For instance, the cliff at the river bank, just where the road from the west along the north bank comes to the ford at the mouth of Lick Run, is a mass of sandy limestone, near the bottom of the Lower Silurian system. Further up the north bank of the river, east of Lick Run, is a long limestone hill on which many pieces of the ore are scattered, some of them very large. There is a good chance here for the existence of a valuable iron-ore deposit on a large scale. The ore is good.

THE COAL FURTHER EAST.

I made no detailed examination above Lick Run for a good many miles; and I have mentioned in a Summary Report the streams crossed by the coal beds in this interval. I will only add here, that some of these beds were *reported* to me as ten (10) feet thick. The six-foot bed may become thicker at points which I did not visit than it is where I saw it.

The "Mouth of Indian" is a thriving little village on the north bank of the Clinch where it enters Russell County. I surveyed this neighborhood carefully, because the coal beds here have been opened more extensively than elsewhere; because they stand at a higher angle and give a series; and because the downthrow is exhibited in a most curious and instructive manner. The river breaks through limestone just above Indian Creek mouth, forming bluffs called the Cedar Bluffs. A dam was built here forty years ago out of red cedar logs which has never needed repairs. It is fifteen feet high and backs the water two miles. Middle Creek descends from the north and enters just below Indian Creek.

Up Middle Creek are the coal mines. See the following map:

Two miles further down the river, Big Creek runs across the upper end of the wide and fertile bottom called the "Rich Lands," at the farm of Mr. Gillespie.

Two miles further west, a salt well, 354 feet deep, was sunk at the north edge of the river bottom, on Mr. Kendrick's land, twenty-two (22) years ago, and, at 337 feet, went through 6.7 (six feet seven inches) of

coal. Six feet at the top of the well was mud. All the rest was "sandrock," without coal.

Petroleum.—There was enough oil to grease the rods. The well was plugged up. Recently the plug was knocked out, when *fresh* water spouted from the 3½-inch hole to a height of three feet, but soon subsided. A film of oil stands on the water, which is very cold and too brackish to taste perfectly good, although cattle go to it in preference to drinking other water.

Salt.—The spot selected for the well had been a famous deer and buffalo lick. The ground had been eaten away by the animals. Thirty or forty deer used to be seen at one time at this lick; and spoonfuls of salt could be collected. It must be borne in mind that the salt wells of Eastern Kentucky get their water from the conglomerate at the base of the Coal Measures. There must, therefore, be a saltwater-bearing formation several hundred feet below the coal bed at the bottom of this well; supposing, 1, that it is the Six-foot Bed of Wise County; and supposing, 2, that the Sheep Rock Conglomerate Sandstone is *not* the true Conglomerate Base of the Coal Measures. But even if the latter supposition be wrong, and the Six-foot Bed be one of the Sub-Conglomerate Coal Beds of Eastern Kentucky, which is quite a possible thing, there remains a still lower "Knobstone," or Devonian Saltwater-bearing Formation, from which the salt water must find its way to the surface through the Great Downthrow and cross-fissures connected with it. This Devonian Saltwater-bearing Formation is that which supplies our deep salt wells in Western Pennsylvania, and is also the same as the Petroleum-bearing Formation of Venango County.

THE COALS AT MOUTH OF INDIAN.

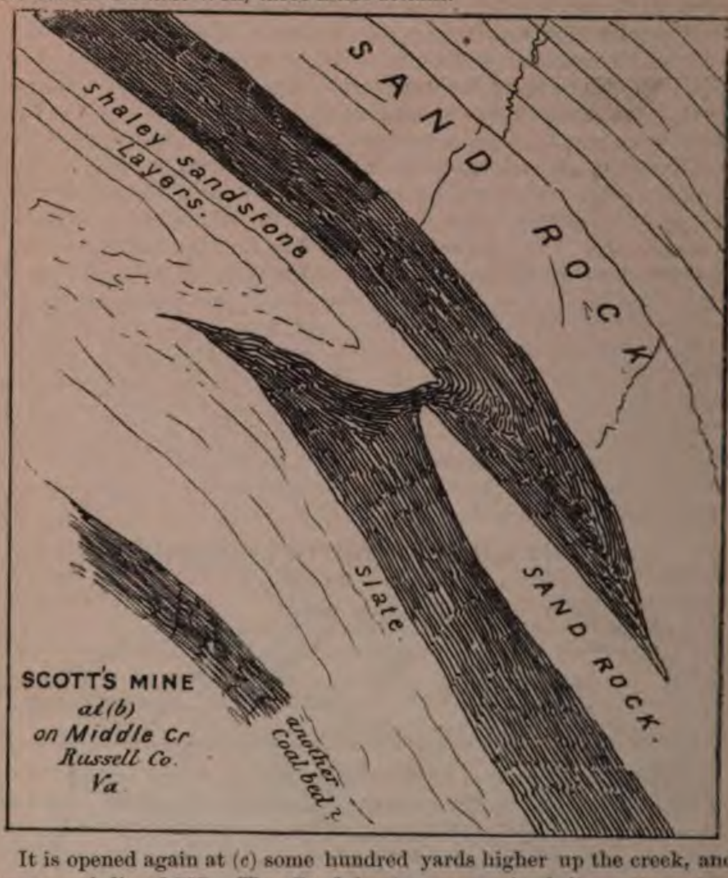
(Section No. 6 of the Map.)

The Six-foot Coal Bed, here, has been opened and mined for the use of the neighborhood by Mr. Scott, at (*a*) about 1½ miles up the creek from its mouth; and again at (*b*) a quarter of a mile further up, on the same south dip. At both (*a* and *b*) it shows a disturbance represented in diagram on the next pages.

The bed is here, really, but 2½ to 3 feet thick. It is covered with a plate of sandstone which is several feet thick; and, although the pressure produced by the Great Downthrow, which runs along at a distance of about half a mile due south of the locality of the mine, has folded the coal bed *with* the sandrock back upon itself, yet the sandstone of the rock, thus caught in between the walls of the fold of the coal, is perfectly solid and does not show the slightest trace of disturbance. This is a striking, but well-known phenomenon. The coal itself is bent round, and shows sharp tongues, in the fold.

At (*b*) the same sandrock is equally folded and unbroken, as the following diagram (looking in the opposite direction, *i. e.* east) will explain.

Here, also, the bed, which when doubled measures 5 or 6 feet thick, is really but a three-foot bed. There is nothing, in fact, to identify it with the "Six-foot" coal of Wise County. But it may very well be the 6.7 coal of the Salt Well, three miles distant.



It is opened again at (*c*) some hundred yards higher up the creek, and on a *north* dip of 50°. The Confederate army mined it pretty extensively. It is here three feet thick, in three benches each a foot thick. The top and bottom benches good, the middle bench bony. Over it are three or four feet of slates, and then comes a one-foot bed of bony coal. The report goes that the miners found these two coal beds close together, down below; making thus one very fair *four-foot coal bed*. A diagram on the next page shows the whole exposure in position.

All this is not very encouraging for the coal trade. But the same bed has been opened at (*d*), directly on the crest of the anticlinal, which has here sunk (running in an easterly direction) to the level of the creek. Here

the coal lies flat in the water; and several pits, sunk through it, are deeper than the height of a man. The bed must be nearly, or quite, six feet, and yields good coal (as indeed it does at the other openings); but what its constitution may be I do not know. It is probably subdivided into benches of different qualities; and, no doubt, has some of the slate of the above last section running through it. Its position on the anticlinal will make mining difficult.

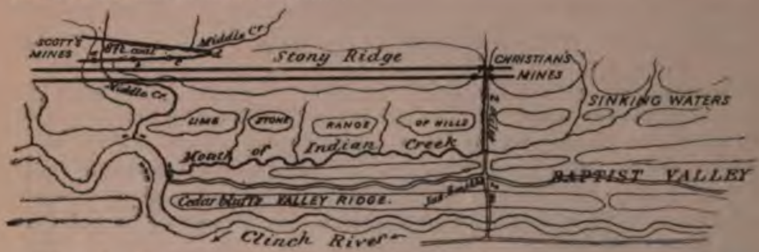
The anticlinal disturbance at Scott's Mines on Middle Creek must be local; because the topography around the Salt Well shows that the Coal Measures *there* come up to the Downthrow in a flat and undisturbed condition; and the dying down of the crown of the anticlinal in the Six-foot bed so rapidly that the bed lies flat in the creek only a few hundred yards above where it plunges at angles of 40°, 50° and 60° proves the same thing.

(a)
APPEARANCE OF COAL BED
at Scott's Mine, Russell Co., Virginia

Nevertheless, the very steep dips of the overlying coal beds and rocks throughout the body of Stony Ridge makes the whole disturbance of considerable magnitude; and I have no doubt that when it is well examined to the eastward, it will be found to run in that direction some miles; not, perhaps, as an anticlinal but as a downthrow; and it may very well be the Abb's Valley Downthrow, of which more hereafter.

LAUREL RUN COALS.

Leaving the curious topography of the Big Creek, Middle Creek, and Mouth of Indian Downthrow to be described hereafter, in connection with Paint Lick Mountain and its Iron Ore, and going east up Indian Creek Valley, I can only report coal mines on Laurel Run, a side branch coming into Indian from the northwest. Mr. Christian has here opened several beds, one of which is reported to be *much over* six feet thick. The coal is wagoned to the county-town of Tazewell, Jeffersonville, fifteen or seventeen (15 or 17) miles distant. The following sketch will show how the coal comes out to market—two miles to James Smith's, on the Baptist Valley Road (beautifully engineered, at low grades), formerly a turnpike, and still the highway between East Kentucky and Middle Virginia; two miles to the Clinch Valley Road; thirteen miles by either of these two roads to Jeffersonville:



What the character of the Christian Coal is I do not know by personal inspection; but it must come from the same beds, and be essentially similar to the Scott Coals, and also to the Abb's Valley Coal next to be described.

Just east of the Christian Mines runs a limestone valley, along the south side of the Downthrow, in which the waters sink into caverns. It is called "Sinking Waters." Any one familiar with Abb's Valley (15 miles further east) will see at once, that the formation is the same; but I will show that Stony Ridge separates the two valleys and that the coal areas which I have been following all the way from Wise County are cut off, or whittled down to a fine point, opposite Jeffersonville. The next cross-section, No. 8, will show how this is done, and also how the Abb's Valley coal beds are brought down to the present surface by quite a different Downthrow from the one we have been tracing thus far, all the way from Guest's River in Wise County; a Downthrow *behind* and to the *north* of this one; as the map in colors will also help to show.

The Clinch Valley Downthrow, going east from Indian Creek, catches in its jaws a less and less number of beds and width of coal ground, until at last, on crossing the great road from Jeffersonville north to Tug Fork of Sandy, it holds but the lowest coal bed, standing at a high angle and very little of it left.

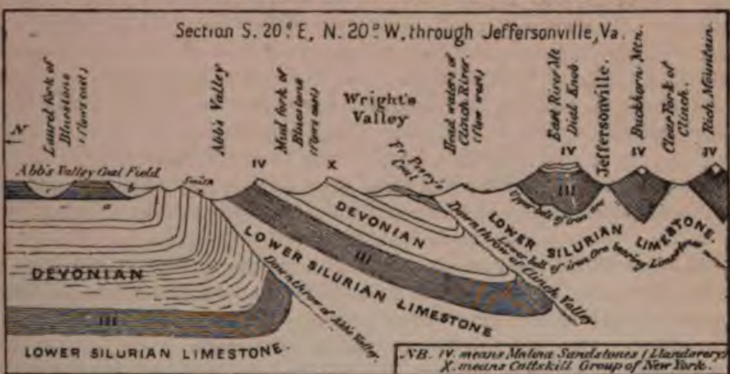
This is seen on the Section No. 8, marked Captain Frank Peery's Coal. How far east along this crack this coal can be traced. I do not know; but nothing of value can be expected from it; which is a great pity; for at this point *easy* access to the back country ends.

To get over into the Abb's Valley Coal Fields, two mountains must be crossed, or, rather steep stony hills, consisting of all the formations from the coal down to the limestone; especially Sandrocks X (Catskill) and IV (Shwangunk) here much diminished in thickness; which accounts for the comparative lowness of these mountains when compared with the high mountains formed by the increased outcrops of these formations in the Northern States.

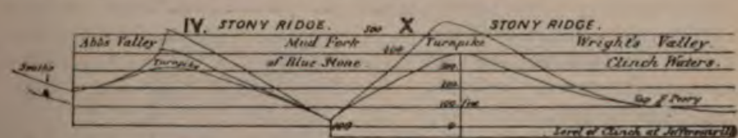
The deep rapid rocky bed of Mud Fork of Bluestone lies between the two mountains and descends eastward. Where the turnpike crosses it it is 400 feet below the notch in the crest of the first mountain, X (say 550 feet below the crest itself); and 250 feet below a slight notch in the crest of the second mountain, IV. This crossing of Mud Fork is, by barometer, on a level with the Jeffersonville Court House, and about 100 feet higher than the Clinch two miles east of Jeffersonville, at the west end of Wolf Creek Valley.

(Cross Section No 8, on the Map)

SHOWING THE ABB'S VALLEY DOWNTHROW.



The turnpike summit crossing the first mountain (X) is 300 feet above Captain Frank Peery's, on the head-waters of Clinch ($6\frac{1}{2}$ miles north of Jeffersonville). Clinch and Bluestone run in opposite directions along Wright's Valley; Clinch westward, Bluestone eastward. The divide between them is about $1\frac{1}{4}$ miles east of the turnpike, at Frank Peery's, and say 100 feet higher in level. This route from Greenbrier to Tazewell is feasible, but it is needless to try to get coal out that way.



Mud Fork of Bluestone heads up rapidly westward of the turnpike, and yet the valley between X and IV must continue on between the two Stony Ridges from the very necessities of the case.

Abb's Valley is produced by a great upthrow of the Lower Silurian limestone against the Coal Measures. The turnpike enters it almost at its head, or western end. From the notch in IV through which the road passes, to the Dry-water course in the centre of the valley is a descent (by barometer) of only 110 feet. Westward the valley rapidly fills up, and that is the course to take in locating a railroad from the mines out to Jeffersonville. A feasible route may be obtained, I think, by keeping up Abb's Valley to and over its divide, and down Cavitt's Run to the Clinch, two miles west of Jeffersonville.

The cause of the heading up of Abb's Valley and Mud Fork Valley so suddenly westward, and against what seems to be the main body of the Tug Fork of Sandy Coal Measures, is a most interesting and important affair, which should be investigated. I can only conjecture it. I take it to be likely that the Abb's Valley Upthrow of limestone starts across the Measures southwestwardly, becoming less and less of an upthrow, and thus swallowing down from the surface first, the Lower Silurian limestones of Abb's Valley, and then the shales and sandstones of the two stony ridges IV and X; and that it finally merges in the Clinch River Upthrow. At all events, such a geology would result in a topography of this sort: The limestone and shale valleys would head up suddenly against a ridge composed of Coal Measures Conglomerate or Sandrocks.

My advice is, that no coal-freight railroad line be sought for in the direction taken by the Jefferson and Tug Sandy Turnpike. But, on the contrary, that a line be sought further west, more down the Clinch, viz.: up Cavitt's Creek. Let the coal beds there be carefully explored, and a line be found across the divides beyond the west line of Abb's Valley.

ABB'S VALLEY COAL.

Fifty feet below the summit of the hill, shown in the "Local Map" on the next page, and nearly 150 feet above the coal bed at its base, is a layer of very coarse, gray, friable sandstone, weathering yellow, without pebbles. Over it a tree has turned up a coal crop.

The coal bed below is, perhaps, the only workable bed of this district. For, after descending, at a slope of one or two (2°) degrees, south 20° east, through the base of the hill, and getting under water level, it seems to turn up suddenly and quite vertically, and to outcrop along the bottom of a little valley. It has been mined a little close to the turnpike (*b*) and Mr. Smith reports it to be "as wide as a room."

Ten miles east of this, and in a similar position, a coal bed is mined, which I judge to be the same one, and it is called ten (10) feet thick.

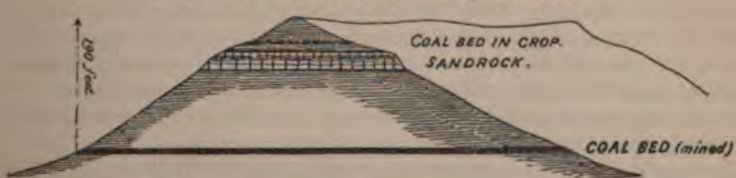
In the openings at the foot of the hill (at *a*) it has been merely thrown out from the water of the little brook. Mr. Cochrane, who has dug coal all through this region, gives its thickness as (5) five feet of coal in 5¾ of space. A dirt bed, four inches thick, separates the lower bench of very fine coal from the upper and main body of the bed.

This coal bed is dug into by the farmers, at several places on the hill-sides of Laurel Fork, from half a mile to several miles north of Smith's coal. It is called six feet thick. Cochrane says he has dug it on Laurel where it was good seven feet.

LOCAL MAP OF ABB'S VALLEY COAL.

(Properly Blue Stone Coal.)

CROSS SECTION OF COAL IN HILL.



The level of the coal opening is (by barometer) 115 (one hundred and fifteen) feet above Smith's house; which house is 125 feet below the summit of turnpike crossing, Stony Ridge (No. IV). [See p. 504.] The coal and the turnpike summit are, therefore, nearly on a level.

From these coal outcroppings just back of Abb's Valley the coal field

of West Virginia and Eastern Kentucky extends, without a break, to the Ohio River. And the south edge of this coal field is the north ridge of Abb's Valley. The coal beds can be opened anywhere in the hills, just north of Abb's Valley; and several low windgaps, similar to that at Mr. Smith's, give the people of the valley access to the coal field. But, as I have said before, the railway line which passes through Tazewell must approach the coal field from the west—not from the south; around the head of Abb's Valley, from Cavitt's Creek. This will also subserve the interests of any railway projected from the Ohio River up Tug Fork of Sandy to Jeffersonville.

(N. B.—I do not feel entire confidence in my geology of the sandstone ridges at Smith's,—the ridges which form the north boundary of Abb's Valley. They need much more careful study than I could give them.)

THE IRON ORES OF II AND V.

The valleys of Tazewell and Russell, in Virginia, being geological, as well as geographical, prolongations of the interior limestone valleys of Pennsylvania, such as the Nittany, Morrison's Cove, and Kishicoquilis, contain necessarily the same kinds of ore, in the same formations, and in the same conditions. I mean that the unbroken ground is at present covered with patches of brown hematite "blossom," just as the ground used to be where our charcoal furnaces stand; and that the color of the road and field soil is the same as that of our best iron ore banks; the limestone rocks project in the same style, have the same internal composition, and exhibit the same corroded and dissolved surfaces; and potholes, caverns, and sinks abound along certain lines of outcrop. All these things are now known to bear an intimate relationship with both the original setting free of the mineral iron from the limerocks, and its subsequent deposit and consolidation. And it seems to be becoming clear to our geologists, that while there are regularly stratified beds and belts of the ore at two or three distinct horizons in the Lower Silurian Limestone Formation, which may be traced for many miles along the strike of the rocks, there are also vast accumulations of this brown hematite ore along anticlinal axes, especially wherever these are fractured; or degenerate into pure upthrow faults. It stands to reason that such a line of fracture, with a high wall on one side of it, should, in the course of thousands of ages, have collected vast quantities of the peroxidized iron which was being, through all these ages, set free in the slow dissolution of the limestones and the reduction of the whole mass of upheaved country to its present level. To say nothing of the facility afforded by such fissures to the decomposing and recomposing agency of drainage waters.

It is along the great upthrow fissures, then, that we are first to seek the iron ore deposits of this section of Virginia. And such a spot was pointed out to me near the mouth of Lick Run, on the hills bordering the north bank of the Clinch River, in Russell County, at section line No. 4 upon the map. Large masses of "blossom" lie scattered about the fields.

Similar shows of ore occur in other places. The hills southeast of Jef-

fersonville, just outside the town, show the existence of ore beneath the surface. Great quantities are reported two miles east of the town; and still more abundant exhibitions in the cove of Wolf Creek, behind Buckhorn Ridge, north of the forks of Wolf Creek, and opposite Rocky Gap. Immense shows are reported in Wolf Creek Valley, inside of (or south of) Rocky Gap.

I have myself no doubt of the correctness of these reports, so far as surface exhibitions are concerned. And it is an old and good iron master's maxim, that where there is plenty of blossom there will be plenty of good ore. The fact is geologically exact. For the blocks of ore on the surface of limestone land (like the masses of white quartz on the surface of a mica slate country) are the undissoluble parts of the original country left behind by the slow and imperceptible mouldering away and removal of the softer material.

A downthrow fissure, also, traverses Wolf Creek, at the foot of Clinch Mountain, as shown in the following continuation of section 8, and this fissure brings the No. IV sandrock of the mountain (which surrounds Burke's Garden) at a dip of 30°, down against the limestone of the valley. How far this fissure extends eastward I do not know; but certainly beyond Rocky Gap.

CONTINUATION OF SECTION No. 8 (OF THE MAP) SOUTHWARD.

There is also a sharp, broken anticlinal axis running through the valley of the Clear Fork of Wolf Creek, and this would favor the accumulation of iron ore. Another traverses the cove behind Buckhorn Ridge, cutting it off from East River Mountain. It is on this anticlinal that the Wolf Creek Cove ores exhibited.

But there is another important fact not to be lost out of view. Throughout Southern Pennsylvania, and as far eastward (along the belt of which we are treating) as the Lehigh and the Delaware, and so on through New Jersey in the one direction, and through Maryland and Virginia in the other direction, the horizon (or formation level) of the bottom of the Lower Silurian (formerly called "Hudson River") Slates, No. III, and the top of the Lower Silurian Limestones, No. II, is a plate of brown hematite iron ore-bearing rocks. Many of our best and oldest mines, like the Balliott and the Moselem, between the Schuylkill and the Lehigh, are on the outcrop of this horizon, at the top of the limestone formation. Where

the dip is low and the slates of No. III are thick, this line runs through the middle of our limestone valleys. Where the dips are steep and the Slate Formation No. III is not so thick, the latter forms the flank of the mountain, and the iron ore line runs at the base of the mountain. Where a closely folded anticlinal makes the valley so narrow that the two bases of the opposing No. III Mountains touch each other, and the ridge of the limestone formation No. II, juts up along the water course, or does not quite come to the surface (as in the three valleys at the left hand side of the above Section No. 8), the iron ore deposits must be abundant.

Holding these simple principles of structure in mind, it is evident that the great iron bearing formation, at the base of the No. III Slate Formation, keeps its character all through Middle and Southern Virginia, and will be as rich and certain a basis for large iron mining and iron smelting operations as any other and better known section of the Appalachian Mountain Belt between New York and Alabama.

An old forge at the west end of Paint Lick Mountain (between Lebanon and Jeffersonville) used this top-limestone-horizon ore; and I have no doubt of its abundance in many other places. It is more constant and regular than the ores further down and near the bottom of the Limestone Formation No. II. And these, moreover, are often swallowed up to such a depth by the downthrows as not to be attainable for many years.

It remains to notice a quite different variety of iron ore, which, I hope, will prove sufficiently abundant at a few points along your line of road. It is the Fossil Ore of V; the Paint or Dye-stone Ore of Tennessee.

To describe the situation of this ore, I must refer to the map accompanying this paper. I have colored Formation No. V, the red shales of the Clinton Group, with the color which I gave it on the State Geological Map of Pennsylvania. This color, however, is not appropriate to the formation in Southern Virginia; for the *red soil* and *reddish* (Upper Silurian) *sandstones* which mark the slope sides of our Pennsylvania Mountains (of No. IV), gradually disappear as one goes south from the Potomac, giving place to a gray soil and very slightly, often not at all, reddened sandstones and slates. On the other hand, the opposite side of the mountain, where the basset edges of the (Lower Silurian) slates of No. III crop out, is very red. A Pennsylvanian geologist floating over the country in a balloon would naturally make the mistake of just reversing the geology of the mountain, and would descend upon the wrong side of it to seek for the well-known and highly prized fossil ore bed of Danville and Frankstown.

In spite of this change of color in the formation soils of the region, I have thought it best to retain the red color for No. V upon the map, seeing that it represents the blood-red color of the fossil ore itself. One may see, then, by tracing the lines of color on the map, where the fossil ore bed *ought* to be; whether it be there or not. Very extensive and costly explorations have been necessary in Pennsylvania and Maryland. No doubt much research of the same sort will be called for in Virginia. But the ore is there; and, as in Pennsylvania and Tennessee, it will run for

miles together in a workable condition as to size and posture, and prove a source of wealth.

The principal use of this ore is to mix with other varieties,—with the blue carbonate lean ores of the Coal Measures, especially; but also with the inferior grades of brown hematite. The time will come when it will be smelted in connection with the primary ores of the Blue Ridge Range and Smoky Mountains.

The forge which stood many years ago at the west end of Paint Lick Mountain, in Russell County, used this ore, and obtained it from the summit of Short Mountain to the south.

Paint Lick Mountain is named from an exposure of this ore on its summit. The situation is one of peculiar interest to the geologist and to the antiquarian.

CROSS SECTION AT THE ROAD FROM THE CHURCH TO CLINCH RIVER ABOVE CEDAR BLUFFS; AT LYLE'S GAP.

A cross-section, at the road over the mountain, through a notch called Lyle's Gap, will show the cause of the appearance of this ore in so singular a position. It is confined to the very summit of the mountain for some distance midway between the two ends, and to the west of the place where the road crosses. Its thickness and extent is unknown, nor do I think that more than a few thousand tons of it are to be expected. The ore stratum has been swept away from all other parts of the ridge of the mountain, and no trace of it has been left upon Deskin's Mountain; from

PAINT LICK MTN, FROM THE SOUTH; CLIFFS AND ORE.

which, indeed, the great sandrock No. IV has almost disappeared; a few house and barn-like masses being left standing at its western end in most picturesque style. House and Barn Mountain is a prolongation of Paint

Lick synclinal westward and is named from two masses of No. IV, left upon its summit, visible from all the surrounding country. Dial Knob (East River Mountain) and Buckhorn Mountain are prolongations of Paint Lick and Deskin's synclinals, eastward beyond Jeffersonville, and Dial Knob may have a good deal of fossil ore left upon it in the cove, behind the Dial Cliffs; but Buckhorn has lost the ore. So has the whole range of Rich Mountain, from Rocky Gap west, to Morris's Knob, which is terminated by one of the most remarkable cliffs of No. IV I ever saw (see its profile below). Short Mountain is a prolongation of Rich Mountain westward, broadened by a shallow synclinal which must hold large quantities of the fossil ore. The synclinal of House and Barn Mountain is prolonged westward (past Lebanon, far down Clinch River) as a downthrow of the No. V Formation against the limestone of No. II; and all along the south side of Copper Ridge there runs a south dipping plate of

DOUBLE ESCARPEMENT OF No. IV. 200 FT. WALLS,
at the Westend of Rich Mountain. Morris Knob, Russell Co, Va.

the fossil ore, which has been opened, in old times, at one point, and used in a now abandoned forge. There must be immense quantities of the ore in this ridge. It is known to the inhabitants, however, only as a paint. But this will be a sufficient guide to the iron master.

The Indians used the outcrop of the fossil ore bed to paint their faces and lodges. The deposit on Paint Lick Mountains was a famous locality among the Aborigines. On a smooth perpendicular wall of sandstone, facing southward, and visible from General Bowen's house and the Maiden Spring, there remain numerous pictures and symbols of men and animals in red paint, fresh as when first made, and older than the settlement of the country by the whites. I give above a view of this long wall of sandstone cliffs as I saw it from the Lebanon–Jefferson turnpike; and, when taken with the cross-section, it will explain without further words both the structure of this (and other similar mountains) and the cause of the small amount of fossil ore left upon its summit, and the total disappearance of the last remains of the ore deposit from the summits of House and Barn, Desmit, Buckhorn, and Rich Mountains.

But there are extensive outcrops of the fossil ore of No. V along Poor Valley; in fact the deposit (whether rich or not remains to be discovered) runs uninterruptedly more than a hundred miles in an almost mathematically straight line along the south flank of the Clinch Mountain from

Tennessee, past Moccasin Gap, back of Saltville, past Sharon Alum Springs, to Hunting Camp and Kimberling Creeks, and so on, eastward, across New River towards the James River country. No doubt some sections of this line hold the ore bed in a lean and, perhaps, unworkable condition; but it is quite incredible that other sections will not have it both thick and rich.

Now it is along this Poor Valley and its outcrop of iron ore that Gen. Haupt locates the line of railway.

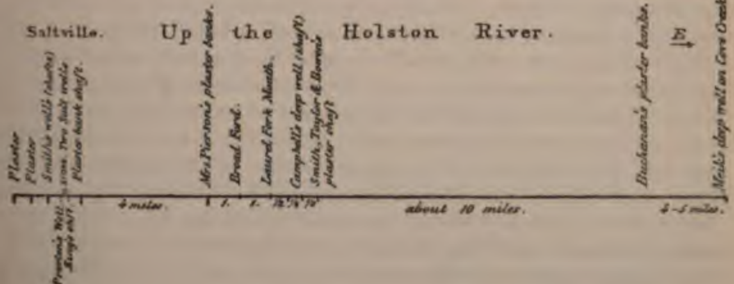
Even if the Clinch River line be adopted, for the sake of the coal and for other reasons, a branch road must certainly be made up Hunting Camp Creek to the Plaster Banks, at Saltville; and this branch will have the ore crop of Poor Valley, and the ore deposits of Tumbling Run, on top of Short Mountain, at its command. It can bring the fossil ore forward to the Forks of Wolf Creek, where are the before mentioned large deposits of brown hematite ore; and where it will meet the coal coming across from the Clinch River. Here, or somewhere lower down Wolf Creek, perhaps at its mouth, will probably be located one of the principal future iron-works of Southwestern Virginia.

THE PLASTER (GYPSUM) BANKS, AT SALTVILLE.

A sound theory of the origin of the gypsum can be, for the present, our only guide to a correct estimate of its quantity, where it is known to exist, and to its discovery elsewhere.

Gypsum may be produced by the action of free sulphuric acid on limestone; or by the action of sulphuretted hydrogen gas on limestone. One or the other, or both of these agents combined, have acted on the limestone rocks along the banks of the N. Fork Holston River, from Saltville, eastward for a number of miles, converting them into gypsum. The acid, whether in a fluid or in a gaseous form, has undoubtedly passed along between the walls of the great fissure which has thrown the Lower Coal Measures of the Poor Valley (Little) Mountain 15,000 or 20,000 feet down against the limestones; has soaked into the walls of the fissure; and has changed the limestone to gypsum for many yards on each side of the crack. Shafts have been sunk through solid masses of gypsum rocks thus formed to a reported depth of 500 and 600 feet, finding no bottom to the gypsum.

The story of this shafting as given to me by General Bowen is as follows:



Captain Smith and his son-in-law Mr. Robinson many years ago sank a line of shafts across the (tertiary or postertiary) plain on which Saltville stands, and *all of them* through gypsum *all the way down*. Others were sunk by Smith & Robinson, Campbell, Taylor & Bowen, Meik and others at other places in the Holston Valley for a length of twenty (20) miles, more or less, and up Cove Creek four or five miles still further east. No attempts were made to get the plaster further on towards Sharon Alum Springs; but there is nothing to intimate its non-existence except the absence of outcrops through the soil. These outcrops naturally existing, or accidentally exposed in farming, or by the railroad cuttings south and west of the village, have alone (as it seems) determined the search after gypsum in the valley. And as the Saltville people alone have any proper machinery for sending it to market, a stop has been put to all exploration elsewhere.

Moreovor, seeing that Capt. Smith struck a copious brine in two of his wells, the opinion early prevailed that the salt and the gypsum were geologically connected. This opinion induced a number of persons to sink *in the gypsum outcrops* not for gypsum but *for salt water*. As salt water was obtained in no single instance other than Capt. Smith's two wells, all hope of obtaining brine and making salt elsewhere than at Saltville has been long since abandoned; and consequently all exploration of the gypsum rocks, which had no commercial value to the salt-well borers.

It is therefore probable that the limestone wall (the south wall) of the Holston River Downthrow (Upthrow of limestone) will in course of time be discovered to be converted into gypsum at other points besides those specified above; and that the gross quantity of gypsum existing beneath the surface along this part of the Holston River far exceeds any estimate which I can make from the gypsum banks already opened. And for the same reason it is probable that the limestone walls of the other Upthrows of the region will be found turned into gypsum, at least in certain places, and in very considerable abundance.

The appearance of brine in such quantity and of such strength must be considered as a local phenomenon explainable without reference to the gypsum. Such an explanation may be found in the very curious lake-deposit of the little triangular plain of Saltville; a deposit evidently made in a deep little lake or pond basin filled with red mud saturated with salt-water, gypsum drainings, &c., &c. In this mud the salt-water has deposited rocksalt, and from this rocksalt deposit now rises the copious discharge of brine which furnishes all the supply needful for the extensive salt works. The salt lies in solid form, mixed and inter-stratified with compact red marl or clay, 200 feet below the water-level of the Holston; and the borings have gone down (at the Salt Works) 176 feet further without reaching the bottom! On the top of the deposits of salt and mud is a stratum of blue slate more than 100 feet thick. Over the blue slate lie 60 or 80 feet of gypseous clays. The limestone country being cavernous to great depths, and especially along the face of the Downthrow, it is not surprising to notice that the level of water stands the same for all the wells and shafts sunk at Saltville and rises and falls in sym-

pathy with the Holston River. This accounts for the inexhaustible supply of liquid. The heaviest pumping has no perceptible effect in lowering the level.

In 1853 the salt yield was 300,000 bushels; 50 lbs. to the bushel, and 6 bushels to the barrel; at 50 cents a bushel. Five furnaces were then running 24,000 gallons of brine pumped daily; 10,000 cords of wood burned yearly.

During the Civil War, four wells were pumped night and day for six months, and yielded 1,000,000 bushels of salt during that half year. There were then sixty-nine different "blocks of kettles" going. These kettles, broken and rusty, lie scattered about the valley for six miles, half buried in piles of burnt and broken down walls which represent the various works then in full operation. Some of the salt water was carried in railway tanks nine miles to Glade Spring Station on the Virginia and Tennessee Railroad, and boiled there.

At present there are three "blocks," of 80 kettles each, (5 bushel to a kettle) per 24 hours, making 360,000 bushels per year, of 300 days.

Preston's gypsum banks yielded 2000 tons in 1854; the cost at the mines, in lump, being $3, and in flour $5; eighty miles distant $20.

What the yield has been since and what it is now, I do not know. Operations are vigorously carried on at four or five shafts. Plaster is now sold at the mines for $2.50 the ton; at Sharon Alum Springs, 35 miles to the eastward, at $10, in wagons; and is carried forty miles further east for use upon the soil. Its virtues are well known and highly prized. It *doubles* the grass crop and grain, and greatly improves corn. One bushel of 100 pounds is sown to the acre.

A railway from Saltville east would find a market for all the plaster it carried. Plaster would go east to the Wolf Creek Fork Junction, and return by the other line to be used on the pasture lands of Tazewell and Russell and Wise Counties. But its greatest commercial outlet would be towards Staunton and Winchester.

Although the gypsum rocks have not the regularity of a coal bed, and some difficulties, of a kind peculiar to this district will be encountered when mining operations are extended to cope with the demands of commerce along a great trunk railroad, yet I see no practical limit to the capacity of the gypsum belt for exploration. Shafts five and six hundred feet deep have permitted the miners to feel the gypsum masses for fifty yards in width. Such a mass, limited by such a shaft, weighs six or seven hundred thousand tons, provided the gypsum be solid the entire depth of the shaft, &c., &c. This is not the case; neither, on the other hand, is the *width* of the column of gypsum limited to fifty yards, or to any other figure. Nothing can be more irregular than the masses of gypsum underground—unless it be the course to be taken to get it out to the surface. In spite of all mining difficulties the value and scarcity of the mineral in all other parts of the country must make its mining in this district always extremely profitable, and its railway carriage over long disances inevitable. It must always be in demand; can always pay a high freight charge, and cannot meet with competition from the Nova Scotia plaster until it arrives within a hundred miles or so of tidewater. Westward and southward it may go five hundred miles without meeting competition.

Stated Meeting, Sept. 20, 1872.

Present, nine members.

Vice President, Mr. FRALEY, in the Chair.

A Photograph was received from Mr. A. H. Worthen, dated, Springfield, Ill., August 31, 1872.

Letters of acknowledgment were received from the Congressional Librarian, Sept. 5th (Proc. Vol. 1. Catalogue I., II.), the Boston N. H. S., May 15th (XIV., iii. 86, 87,) and the London Geological Society (XIV., iii. 86.)

A letter of envoy was received from the New York State Library, dated August 30.

A letter describing the Museums and Libraries of Oxford, England, was received from Mr. W. A. Smith, Professor of Moral Philosophy in Columbia, Tennessee, Athenæum, dated, Sept. 14th, 1872.

A letter was received from D. C. H. Stubbs, dated July 8th, 1872, respecting the purchase of copies of Photographs of Indian Sculpture. On motion the Secretary of the evening was authorized to purchase a set after due examination of their value.

Donations for the Library were received from the Horticultural Society in Berlin, the Prussian Academy, the Observatory at Turin, the Geographical Society, Revue Politique, and Lartêt family at Paris, the Edinburg Observatory, the Meteorological Office in London, Nature, the Canadian Naturalist, Essex Institute, Old and New, Dr. S. A. Green of Boston, American Antiquarian Society, American Journal of Science, and Professor O. C. Marsh of New Haven, American Chemist, Mr. W. W. Mann, the Dudley Observatory, New York State Library, N. J. Historical Society, Franklin Institute, Medical News, Journal of Pharmacy, and Prof. Edwin J. Houston of Philadelphia, the Petroleum Monthly, the U. S. Observatory, Bureau of the Interior, Prof. F. L. O. Röhrig, the Smithsonian Institution, Bureau of U. S. Engineers, and the Wisconsin Historical Society.

The death of Mr. Jacob R. Eckfeld at Haverford, near

Philadelphia, August 9th, aged 70, was announced with appropriate remarks by Mr. Patterson.

On motion, Mr. Dubois was appointed to prepare an obituary notice of the deceased.

The death of Dr. John Bell of Philadelphia, August 19th, aged 77, was announced by the Secretary.

On motion, Dr. B. H. Coates was appointed to prepare an obituary notice of the deceased.

Communications were received from Prof. E. D. Cope under the following titles:

Third account of New Vertebrata from the Bridger Eocene of Wyoming Territory.

Notices of New Vertebrata from the upper waters of Bitter Creek, Wyoming Territory.

Second notice of Extinct Vertebrates from Bitter Creek, Wyoming Territory.

On the existence of Dinosauria in the Transition beds of Wyoming Territory.

On the Dentition of Metalophodon.

The Secretary announced that he had received a telegram from Prof. Cope, dated Black Buttes, Wyoming Territory, August 17th, announcing the discovery of Lefalophodon dicornutus, bifurcatus, and excressicornis, Cope.

Prof. Edwin J. Houston called the attention of the Society to a remarkable instance of the acoustic sensitiveness of matter. "While visiting a number of water-falls on Adam's Brook, Pike Co., Pennsylvania, I noticed one in which a scanty supply of water was dripping, in thin delicate streams, from the moss covered walls of a precipice. The day was unusually calm, and the veins were remarkably free from ventral segments for a considerable distance from the filaments of moss from which they issued. Struck with this circumstance the idea occurred to me to test the sensitiveness of the stream to sound pulses. I made the attempt, and after several trials found a note, a shrill falsetto, to which they would respond.

The experiment was one of extreme beauty. At one point

of the falls, there were no less than one hundred of these streams, and on sounding the required note the groupings of the drops and the positions of the ventral segments instantly altered in quite a marvellous manner. This case of acoustic sensitiveness is one of the most extensive I have ever noticed.

A second fall was found that would respond to certain notes, though it was not equal to the first in sensitiveness.

Though not able, from a sudden flooding of the streams, to discover the exact conditions for success, I believe the explanation of the phenomenon to be the same as that now generally given for sensitive smoke and water jets, viz: that the sound pulses produce a vibration of the orifice of the jet, by which the constitution of its issuing stream is altered. The orifice in the case is replaced by the thin moss filaments, which are surrounded by the stream instead of surrounding it. From their shape and position their filaments, acting as reeds, readily accept the motion of the sound waves and so alter the constitution of the vein."

Prof. Chase communicated observations on Daily Auroral and Meteoric Means, and on some new correlations of stellar and Planetary distances.

Mr. Lesley described a newly observed terminal moraine crossing the Walkill Valley at Ogdensburg near Franklin, Essex county, New Jersey.

Pending nominations, Nos. 697 to 701 and new nomination No. 702 were read.

The meeting was then adjourned.

DAILY AURORAL AND METEORIC MEANS.

By Pliny Earle Chase.

(*Read before the American Philosophical Society, Sept.* 20, 1872.)

The apparent influence of meteoric falls upon auroras, which is indicated by the five-day means, (*ante* p. 402), renders more minute observations desirable, in order to ascertain to what extent a similar influence may be traceable in the daily means.

The only available observations that have fallen under my notice, from which any satisfactory approximation can be made to the daily meteoric curve, are embodied in Baumhauer's table of the recurrences of meteoric stones and fire-balls, quoted by Lovering, ("on the Periodicity

of the Aurora Borealis," p. 220). Lovering observes that the days signalized by the frequency of these phenomena are also days which, according to Quetelet, are distinguished by extraordinary numbers of shooting stars. I have grouped the second means of Baumhauer's numbers in five-day periods, and calculated the ratio of each ordinate to a mean ordinate of 100, in order to justify the following comparison with the auroral ordinates, which were similarly computed from Lovering's table.

FIVE-DAY AURORAL AND METEORIC NORMALS.

(A.=Auroral, *Lovering.* M.=Meteoric, *Baumhauer.*)

	A.	M.		A.	M.
January 3,	110	119	July 2,	40	35
" 8,	110	128	" 7,	46	51
" 13,	114	116	" 12,	44	83
" 18,	113	96	" 17,	40	113
" 23,	I10	89	" 22,	39	121
" 28,	111	98	" 27,	45	121
Feb. 2,	113	111	August 1,	49	136
" 7,	116	115	" 6,	51	160
" 12,	125	105	" 11,	60	160
" 17,	133	91	" 16,	76	134
" 22,	134	90	" 21,	88	103
" 27,	132	97	" 26,	95	74
March 4,	129	103	" 31,	102	65
" 9,	133	106	Sept. 5,	112	86
" 14,	145	101	" 10,	123	110
" 19,	144	88	" 15,	131	106
" 24,	138	82	" 20,	138	88
" 29,	138	91	" 25,	142	86
April 3,	133	103	" 30,	139	99
" 8,	130	108	October 5,	133	108
" 13,	131	98	" 10,	129	108
" 18,	118	76	" 15,	129	108
" 23,	94	63	" 20,	133	111
" 28,	79	66	" 25,	132	105
May 3,	76	69	" 30,	126	95
" 8,	66	71	Nov. 4,	120	106
" 13,	61	86	" 9,	121	143
" 18,	57	100	" 14,	129	170
" 23,	51	96	" 19,	127	156
" 28,	47	88	" 24,	113	132
June 2,	44	85	" 29,	109	125
" 7,	44	82	Dec. 4,	115	125
" 12,	41	73	" 9,	122	125
" 17,	35	57	" 14,	127	123
" 22,	31	38	" 19,	125	111
" 27,	36	31	" 24,	114	99
			" 29,	111	103

In each curve there is a tendency to monthly maxima, the tendency being least evident in the summer months.

The principal minimum in each curve is in June.

There are nine marked maxima in each curve, of which those in the months of January, February, March, April, September, October and November, are the most nearly accordant. These maxima are as follows :

A. Jan. 13. Feb. 23. Mar. 16. Apr. 13. . . . . July 7. . . . . Sept. 25. Oct. 20. Nov. 14. Dec. 14.

M. Jan. 8. Feb. 7. Mar. 9. Apr. 8. May 18. . . . . Aug. 6. Sept. 10. Oct. 20. Nov. 14. . . . .

Two of the maxima are synchronous in the two curves ; three occur in the auroral ordinate which follows the meteoric ordinate ; two occur in the third subsequent ordinate, one of the two being midway between a precedent and subsequent meteoric ordinate. The accordances and the discrepancies may perhaps be explained by the hypothesis of lunar perturbations.

The daily curves present a similar accordance in the number of maxima and minima, but in consequence of the frequent uncertainty whether the auroral or the meteoric should be regarded as the precedent influence, they do not seem to furnish any additional data for satisfactory conclusions.

By variously grouping the auroral observations on each side of the days that have been designated by Wolfe and Kirkwood as rich in meteoric displays, or on each side of the middle days of meteoric periods, a variety of curves may be formed, of which the three following sets of ordinates furnish examples :

Days.	—7	—6	—5	—4	—3	—2	—1	0	+1	+2	+3	+4	+5	+6	+7
α	100	99	100	102	104	106	106	104	103	105	107	108	106	101	99
β	99	99	97	97	97	99	101	101	100	101	102	102	104	104	102
γ	103	102	101	98	97	98	98	99	101	101	101	103	105	101	98

These curves indicate a connection of meteoric displays with increasing auroral displays, together with a slight subordinate tendency to auroral maxima within one day of a meteoric display.

Although the æthereal disturbance, which is manifested by the auroras, appears to follow, more often than it precedes, meteoric falls, it seems probable that both phenomena are often dependent upon lunar perturbations or other extraneous causes. In such cases, the auroras may become visible before the meteors have reached the earth's atmosphere, and been made incandescent by friction.

STELLAR AND PLANETARY CORRELATIONS.

By Prof. Pliny Earle Chase.

(*Read before the American Philosophical Society*, *Sept.* 20, 1872.)

Mercury's mean distance may be grouped with the mean distances of other primary planets, so as to form the two following series :*

* In each table, C denotes the logarithm of the computed value; O, the logarithm of the observed value; E. the percentage of error in the computed value; L. the limit of retardation by solar rotation and of possible solar atmosphere; M. modulus of light. The fundamental unit is the suns's radius. The origin of the co-ordinates is taken at the intersection of the axis and the directrix.

(I.)

	C.	O.	E.
	.178352		
	.467972		
	.786253		
$\frac{2}{3}$ L	.1.133195	1.135133	—.004
$\frac{8}{9}$ "	1.508798	1.509949	—.003
☿	1.913062	1.910977	—.016
⊕	2.345987	2.332155	+.032
	2.807573		
♄	3.297820	3.311651	—.032
♆	3.816728	3.809811	+.016

(II.)

	C.	O.	E.
	.115730		
	.732349		
$\frac{2}{3}\times\frac{8}{9}$ L	1.335303	1.333858	+.003
☿	1.924592	1.919997	+.011
♂	2.500216	2.513999	—.032
♃	3.062175	3.048392	+.032
♅	3.610469	3.615063	—.011

If the limiting radius of solar retardation (L = 36.4, see *ante*, p. 415) be regarded as also a limit of explosive oscillation, and if radii terminating in the cardinal points of the explosive excursion ($\frac{1}{9}$, $\frac{1}{6}$, $\frac{2}{9}$, $\frac{1}{3}$, $\frac{4}{9}$, $\frac{2}{3}$, $\frac{8}{9}$) be employed for determining a parabolic series, the mean distances of Venus, Earth, and Jupiter, will be represented by succeeding abscissas of the same series, as in Table III.

(III.)

	C	O	E
	.127899		
	.291712		
	.453089		
$\frac{1}{9}$ L	.612030	.606859	+.012
$\frac{1}{6}$ "	.768535	.782950	—.034
$\frac{2}{9}$ "	.922604	.907889	+.034
$\frac{1}{3}$ "	1.074237	1.083980	—.023
$\frac{4}{9}$ "	1.223434	1.208919	+.034
$\frac{2}{3}$ "	1.370195	1.385010	—.035
$\frac{8}{9}$ "	1.514520	1.509949	+.011
	1.656409		
	1.795862		
	1.932879		
	2.067460		
♀	2.199605	2.191493	+.019
⊕	2.329314	2.332155	—.007
	2.456587		
	2.581424		
	2.703825		
	2.823790		
	2.941319		
♃	3.056412	3.048392	+.019

If the determining series be modified by substituting L for $\frac{8}{9}$ L, and employing $\frac{4}{3}$ L for the succeeding determining abscissa, Mercury's perihelion

and aphelion, and the mean distances of Venus, Mars and Jupiter, will be represented by succeeding abscissas of the same series, as in table IV.

(IV.)

	C	O	E
	.047818		
	.187943		
	.330020		
	.474049		
$\frac{1}{9}$ L	.620030	.606859	+.031
$\frac{1}{6}$ "	.767963	.782950	—.035
$\frac{2}{9}$ "	.917848	.907889	+.023
$\frac{1}{3}$ "	1.069685	1.083980	—.033
$\frac{4}{9}$ "	1.223474	1.208919	+.034
$\frac{2}{3}$ "	1.379215	1.385010	—.014
1 "	1.536908	1.561101	—.057
$\frac{4}{3}$ "	1.696553	1.686040	+.025
☿ I	1.858150	1.850507	+.018
☿ II	2.021699	2.021443	+.000
♀	2.187200	2.191493	—.010
♀ ⊕*	2.354653	2.353070	+.004
♂	2.524058	2.513999	+.023
	2.695415		
	2.868724		
♃	3.043985	3.048392	—.010
☿ — ♆†	3.221138	3.211038	+.024

In a communication which I presented to the Society, May 16th, 1872, I indicated some simple relations between the superficial gravity and the times of rotation of the Sun, Jupiter and the Earth. If those relations are, as I believe, determined by an influent force, we may reasonably look for some analogous relations between our own and other stellar systems.

In the solar-focal parabola which passes through α Centauri and has its directrix in a linear centre of oscillation of a solar diameter, twenty-seven successive abscissas may be taken in regular progression,

$$\left[x_n = \xi^{(n^0)} \eta^{\pm(n^1)} \zeta^{(n^2)} \right]$$

between the star and the Sun's surface, nine of which will be extra planetary, nine will be in simple planetary relations, and nine will be intra-planetary.

The upper extra-planetary abscissa bears nearly the same ratio to the modulus of light, as L bears to solar radius.

The limiting abscissas of the planetary series are determined by combining diametral centres of oscillation ($2 \times \frac{2}{3}$), with centres of explosive condensation ($\frac{8}{9}$), and of explosive oscillation ($\frac{5}{9}$).

The planetary series, between these limits, is $\frac{1}{2}$ ♀, $\frac{2}{3}$ ⊕, $\frac{3}{4}$ ♂, $\frac{4}{5}$ mean asteroid, $\frac{5}{6}$ ♃, $\frac{6}{7}$ ♄, $\frac{7}{8}$ ♅.

* Mean centre of gravity of ☿ and ⊕ at heliocentric conjunction.

† Mean centre of gravity of all the planets, at heliocentric conjunction.

The co-efficient of the inner limiting planetary abscissa ($\frac{4}{3} \times \frac{5}{9}$ ☿) is nearly equivalent to the co-efficient of the exterior intra-asteroidal abscissa ($\frac{3}{4}$ ♄).

The co-efficient of the outer planetary abscissa ($\frac{4}{3} \times \frac{8}{9}$ ♆) is nearly the reciprocal of the co-efficient of the inner extra-asteroidal abscissa ($\frac{5}{6}$ ♃).

The middle abscissa of the planetary series corresponds very nearly with the inner limit of the asteroidal belt (Flora = 2.674854), as well as with $\frac{4}{5}$ of the mean distance of the three principal central asteroids (2.672519), and with $\frac{4}{5}$ of the geometrical mean between Flora and Cybele (2.683640).

Between modulus and the influent centre of solar explosive oscillation ($\frac{8}{9}$ L) there are fifteen abscissas, of which $\frac{5}{7}$ ♄ is the middle one.

Between the Saturnian abscissa and $\frac{7}{9}r$, there are fifteen abscissas, of which $\frac{4}{9}$ L is the middle one.

The abscissas representing centres of effluent or influent explosive condensation ($\frac{8}{9}$ M and $\frac{1}{9}$ L), are similarly situated with reference to the intermediate planetary belt.

No probable values can be assigned to the cardinal abscissas (α Centauri and $\frac{4}{9}$ L), which will produce deviations of the theoretical from the observed values of a higher order of magnitude than the planetary eccentricities.

Henderson's first estimate of the parallax of α Centauri was $1''.16$. Maclear's observations, in 1839–40, gave $''.9128$, and his more extended series, 1839–48, gave $''.9187$. Norton adopts $''.913$; Lockyer, $''.9187$; Denison, without assigning any reason, $''.976$. We may reasonably regard Norton's and Denison's estimates as the limits of probable value, and compute the logarithmic η and ζ from each estimate by the following equations.

$$\xi + 20\,\eta + 400\,\zeta = 7.686009\ (\mathrm{N}),\ \text{or}\ 7.657096\ (\mathrm{D})$$
$$\xi = \tfrac{4}{9}\,\mathrm{L} = 1.208919.$$
$$\xi - \nu\,\eta + \nu^2\,\zeta = -1.221849$$
$$\eta = 2\,\nu\,\zeta$$

Solving these equations we obtain:

$$\eta = .211401 +,\ \text{or}\ .210702 +$$
$$\zeta = .005622 +,\ \text{or}\ .005585 +$$

In the following table, C′ contains the abscissas according to Norton; C″, according to Denison; C‴, according to the actual planetary mean distances. The degree of accordance, between the parabolas which are computed from stellar and solar data and the one which is computed from planetary data, and the evidences of ethereal condensation which are furnished by the gradual lengthening of the observed abscissas, are especially noteworthy.

(V.)

	C′	C″	C‴	O
α Cent.	7.686009	7.657096	7.654826	
L×M	7.255323	7.228566	7.218310	7.215776
	6.835882	6.811207	6.801940	
	6.427687	6.405019	6.396716	
	6.030738	6.010001	6.002638	
$\frac{8}{9}$ M	5.645034	5.626153	5.619706	5.627715
	5.270576	5.273476	5.247920	
	4.907363	4.891970	4.887280	
	4.555395	4.541654	4.537786	
	4.214673	4.202470	4.199438	
$\frac{4}{3}\times\frac{8}{9}$ ♆	3.885196	3.874475	3.872236	3.883597
$\frac{7}{8}$ ♅	3.566964	3.557651	3.556180	3.557071
$\frac{6}{7}$ ♄	3.259978	3.251999	3.251270	3.244704
$\frac{5}{6}$ ♃	2.964237	2.957515	2.957506	2.969211
$\frac{4}{5}$ ✱	2.679741	2.674204	2.674888	2,672519
$\frac{3}{4}$ ♂	2.406491	2.402063	2.403416	2.389060
$\frac{2}{3}$ ⊕	2.144486	2.141093	2.143090	2.156064
$\frac{1}{2}$ ♀	1.893726	1.891294	1.893910	1.890463
$\frac{4}{3}\times\frac{5}{9}$ ☿	1.654212	1.652665	1.655876	1.643972
	1.425943	1.425207	1.428988	
$\frac{4}{9}$ L	1.208919	1.208919	1.213246	1.208919
	1.003140	1.003802	1.008650	
	.808607	.809856	.815200	
$\frac{1}{9}$ L	.625319	.627081	.632896	.606858
	.453276	.455477	.461738	
	.292479	.295042	.301726	
	.142927	.145779	.152860	
	.004620	.007686	.015140	
$\frac{1}{4}$	−1.877559	−1.880764	−1.888566	−1.890856
	−1.761748	−1.765013	−1.773138	
	−1.657172	−1.660432	−1.668856	
	−1.563847	−1.567023	−1.575720	
	−1.481767	−1.484783	−1.493730	
	−1.410932	−1.413714	−1.422886	
	−1.351343	−1.353816	−1.363188	
$\frac{1}{5}$	−1.303000	−1.305089	−1.314636	−1.301030
	−1.265902	−1.267532	−1.277230	
	−1.240049	−1.241146	−1.250970	
	−1.225441	−1.225931	−1.235856	
	−1.222078	−1.221886	−1.231888	
	−1.229961, &c.	−1.229011, &c.	−1.239066, &c.	

CYCLICAL RAINFALL AT SAN FRANCISCO.

By Pliny Earle Chase, Professor of Physics in Haverford College.

(*Read before the American Philosophical Society, July 19th and October 18th, 1872.*)

Although I know of no good reason for admitting that the question, whether the moon exerts an influence upon the weather, is still an open one, there is, undoubtedly, considerable uncertainty as to the value of any predictions that may be based upon such influence, liable, as it is, to local, accidental and variable disturbances, partly of a known and partly of an unknown character. On this account, I think it desirable to collect and discuss all accessible records of observations extending over a period of ten or more years, especially in the neighborhood of sea-coasts and large bodies of water, in order to find how the lunar weather-curves are modified by the forms of continental relief, the average hygrometric condition of the air, the changes of wind, and other obvious or more obscure sources of perturbation. I am willing to devote all the time I can spare from

TABLE I.

Different and non-correspondent Rainfalls at San Francisco, in Lunar and Solar periods, from July 1, 1849, to July 1, 1872. R = Total fall; N = Normal percentage of rain.

☾ Day or ☉ Yr. ÷ 30.	Lunar Monthly							Solar Yearly.						
	Nov. Dec.		Jan. Feb.		Mar.-Oct.		Yr.	1849 + 3n*		1850 + 3n		1851 + 3n		Av.
	R.	N.	R.	N.	R.	N.	N.	R.	N.	R.	N.	R.	N.	N.
1........	6.67	84	8.16	124	1 26	69	97	22.85	319	16.01	287	12.19	273	297
2........	4.93	83	12.69	128	4.74	81	97	28.41	314	14.94	264	6.12	194	267
3........	5.55	82	6.15	115	5.07	97	94	26.26	260	11 15	242	9.84	155	226
4........	5.61	93	6.81	105	5.88	98	92	5.20	190	14 45	238	3.90	165	198
5........	8 52	109	9.26	99	3.18	90	96	14.98	169	13.67	227	11.97	202	194
6........	7.73	121	5.64	84	4.49	92	104	16.81	163	9.97	200	14.57	220	189
7........	9.74	126	2.79	75	5 65	101	107	7.67	140	9.94	171	4.97	213	169
8........	7.96	125	7.55	86	4 55	111	108	10.08	117	8.50	140	15.32	203	147
9........	9.00	120	7 37	97	6.78	119	107	9 11	97	4.41	108	8 04	158	117
10........	7.03	111	7.16	94	6.51	116	103	4 38	69	5.53	84	2.58	86	78
11........	8 12	104	6 04	79	3.86	111	97	3 25	42	3 29	62	.30	46	49
12........	3.91	115	3.54	67	6.15	117	99	1.46	23	1.56	44	4.07	37	33
13........	13.40	138	4.46	72	7 00	129	110	.83	11	2.72	31	.30	24	20
14........	9.47	148	6.89	91	5 62	148	125	.10	5	.16	16	.08	8	9
15........	9.65	137	7.84	113	9 60	172	138	.17	2	.06	5	.05	1	3
16........	9.41	113	10.79	126	11.10	169	134	.00	1	.14	1	.00	1	1
17........	3.87	86	8 03	128	4.96	133	115	.00	0	.00	1	.21	2	1
18........	4 07	78	9.40	126	3 42	111	105	.05	0	.02	0	.00	1	1
19........	7 92	86	10 06	118	8 15	110	104	.01	1	.02	0	.04	2	1
20........	5.34	86	5.69	101	3.99	97	96	.28	2	.00	1	.00	5	2
21........	5.17	82	6.47	92	3.67	72	85	.11	2	.04	3	.79	9	4
22........	5.61	84	6.96	94	2.26	55	83	.04	3	.58	7	.64	12	6
23........	7.37	80	6.36	100	1.91	57	86	.03	9	.40	8	.03	19	12
24........	2.99	70	9 38	101	3.72	79	88	2.14	25	.61	11	2.17	37	24
25........	4.22	71	4.84	96	6.23	87	89	2.67	52	.24	27	3.03	62	47
26........	7.01	79	8.03	90	3.22	76	86	7.63	91	3.16	69	3 71	84	83
27........	5.25	82	5.17	87	2.16	69	81	10.54	140	6.83	125	6 59	102	125
28........	4.31	89	5.52	93	3.92	76	85	14.88	199	13.22	163	3.75	140	172
29........	9.29	103	9.53	105	5.12	85	93	21.81	260	3 51	203	8.26	233	235
30........	7.09	105	6.94	113	4.43	77	96	26.52	300	20 82	261	25.31	307	290

* 1849, '52, '65, '58, '61, '64, '67, '70; 1850, '53, '56, etc., 1851, '54, '57, '60, etc.

daily duties, to such investigations; but the field is so large that I would gladly welcome the co-operation of all who may feel an interest in studies that promise new and satisfactory results as a reward for diligent labor.

The success of the Signal Service Bureau* has demonstrated the importance of careful attention to the most minute indications of possible law, and the influence of the physical geography of our continent upon the weather has been so well ascertained that we may reasonably hope for similar success from a like careful study of astronomical influences. The well-known tendency to weekly meteorological cycles has never been attributed to any more obvious or probable cause than lunar modifications of solar action, and such evidences of cyclical uniformity as have already rewarded my limited researches, encourage me to hope that much of the apparent discordance and supposed accidental irregularity, by which meteorologists are still perplexed, will be finally shown, by broad generali-

TABLE II.

Correspondent Rainfalls at San Francisco, in Lunar and Solar periods.

☾ DAY OF ☉ YR. ÷ 30.	LUNAR MONTHLY.							SOLAR YEARLY.						
	1849–57		1857–64		1864–72		Av.	1849–57		1857–64		1864–72		Av.
	R.	N.	R.	N.	R.	N.	N.	R.	N.	R.	N.	R.	N.	N.
1........	5.32	88	7.15	103	6.07	99	97	16.98	266	16.77	291	17.40	328	297
2........	5.[illegible]3	89	7.76	103	6.50	98	97	14.01	233	17.71	285	17.75	282	267
3........	6.20	94	1.87	82	9.05	101	94	12.98	184	16.63	239	22.64	253	225
4........	6.85	94	4.22	81	5.79	98	92	5.03	159	8.43	198	10.09	232	198
5........	4.27	89	5.50	102	6.82	98	96	9.87	187	11.60	174	19.15	217	194
6........	5.73	91	7.63	119	8.17	103	104	20.62	218	6.76	158	13.97	188	189
7........	6.53	97	6.83	118	6.88	109	107	8.63	200	5.20	172	8.75	140	169
8........	6.18	98	4.44	114	9.28	113	108	11.28	164	17.47	185	5.15	104	147
9........	5.82	94	7.71	123	7.98	108	107	7.55	135	5.02	140	8.30	83	117
10........	5.40	92	7.28	129	7.14	93	103	7.64	104	1.54	78	3.31	54	78
11........	6.03	94	7.18	119	4.64	83	97	2.95	72	3.62	54	.27	26	49
12........	5.79	100	4.81	102	5.13	96	99	3.48	44	2.67	45	.94	16	33
13........	7.22	111	4.55	99	11.21	118	110	.62	21	1.41	28	1.82	14	20
14........	6.78	120	6.10	116	8.92	129	125	.03	7	.20	11	.11	9	9
15........	7.61	147	3.69	139	2.67	128	138	.05	2	.05	3	.18	3	3
16........	10.43	141	10.17	140	11.02	122	134	.12	1	.02	2	—	1	1
17........	6.32	118	4.29	116	6.25	111	115	.00	1	.21	2	—	0	1
18........	3.40	118	5.84	92	7.27	105	105	.02	0	.05	2	—	0	1
19........	13.68	134	3.69	77	9.10	100	104	.01	1	.06	1	—	1	1
20........	6.29	126	3.45	69	4.84	90	96	.00	4	.07	1	.21	2	2
21........	5.93	101	3.83	70	6.33	82	85	.62	9	.12	1	.20	2	4
22........	5.73	84	3.29	81	5.39	84	83	1.14	13	.03	2	.09	3	6
23........	3.94	76	7.22	94	6.83	87	86	.09	21	.03	10	.34	5	12
24........	4.08	82	3.55	99	6.92	85	88	3.37	35	1.15	28	.40	11	24
25........	7.40	95	6.94	98	4.36	78	89	1.49	60	3.10	58	1.35	26	47
26........	6.68	94	4.63	90	5.83	75	86	6.33	103	4.60	92	3.57	58	83
27........	3.97	80	3.56	83	5.64	81	81	11.26	140	7.52	124	5.18	112	125
28........	4.07	74	5.20	80	4.98	98	85	8.32	163	6.97	158	16.56	192	172
29........	5.24	82	4.30	77	11.74	115	93	9.59	203	11.03	202	12.96	289	235
30........	6.14	88	2.46	84	7.73	112	96	20.09	254	13.35	254	39.21	349	290

* Captain Toynbee's recent discussion, for the British Meteorological Committee, "of the meteorology of the part of the Atlantic lying north of 30° N., for the eleven days ending 8th February, 1870," gives very flattering evidence of the estimation in which this success is held abroad. On page 164, he says: "This paper only deals with eleven days of rather exceptional weather, when a southerly wind prevailed on our coasts. It can only be considered as a first attempt at the style of work which is needed to connect the excellent observations now being taken in America with those in Europe.

zations, to be as completely subject to ascertainable laws as are the motions of the heavenly bodies.

About a year ago, I showed, by my discussions of the Lisbon rainfall (*ante* pp. 178–190), that it is possible, under favorable circumstances, to obtain satisfactory evidence of lunar influence upon the weather, even from a comparison of the rainfall in different cycles of less than six years' average duration. My subsequent discussion of the monthly means of Tennent's San Francisco observations (*Journal of the Franklin Institute*, lxiii. 204–6), led me to hazard certain predictions relative to the tidal rains on the opposite shores of continents, and the influence of opposite winds, or of upper and lower tidal currents. Mr. Tennent has generously furnished me a copy of his daily observations on the rainfall, which so fully corroborate the first and third of those predictions, that I hope to obtain from him an equally complete record of the direction of the wind, in order to have the requisite data for similarly testing the other two. Governor Rawson W. Rawson, C. B., has also kindly consented to provide me with a transcript of observations at Barbados, a station within the belt of the trade winds, and, therefore, favorably situated for such comparisons with the San Francisco observations as may serve

TABLE III.

Normals of Rainfall in Synodic years of Jupiter.

	San Francisco.							Lisbon.	
Syn. Yr. + 30.	1849–60.	1860–72.	1855–70.	Nov. Dec.	Jan. Feb.	Mar.-Oct.	1849–72.	Syn. Yr. + 30.	1855–70.
1	80	150	131	132	120	93	118	16	81
2	116	154	141	151	146	98	136	17	88
3	157	111	117	133	144	112	132	18	99
4	166	64	81	97	116	124	111	19	108
5	157	50	68	84	87	142	99	20	110
6	142	58	70	97	62	150	96	21	99
7	110	64	65	101	49	117	85	22	86
8	81	63	57	97	46	70	71	23	84
9	87	68	60	112	51	60	76	24	96
10	119	99	89	127	94	86	108	25	107
11	138	144	128	144	158	113	141	26	112
12	120	159	133	132	170	111	141	27	113
13	81	149	98	122	132	91	118	28	115
14	60	146	75	117	105	82	107	29	120
15	72	131	79	120	95	94	104	30	122
16	83	90	78	90	77	100	87	1	117
17	71	63	64	63	62	82	67	2	103
18	55	70	57	58	64	71	63	3	86
19	55	81	65	61	70	78	69	4	76
20	71	75	78	57	86	79	73	5	76
21	92	68	93	55	100	83	79	6	81
22	103	69	104	63	93	106	84	7	88
23	98	78	107	75	80	121	87	8	96
24	84	97	114	90	81	110	90	9	103
25	77	114	129	102	95	94	98	10	108
26	101	125	157	109	126	107	114	11	113
27	132	127	177	115	148	122	129	12	116
28	124	114	157	109	153	110	119	13	112
29	93	102	120	91	108	96	98	14	98
30	75	117	111	98	101	95	98	15	84

to strengthen the inferences which I have already published, and, perhaps, supply additional data of a novel character.

The accompanying tables and curves are constructed on the same plan as those in my previous meteorological papers. The scale and the degree of smoothing by successive means are uniform; the comparative influence of the sun, moon and Jupiter can, therefore, be readily seen at a glance. The vertical lines (0 to 7) in each set of diagrams indicate the mean hour at which the moon or planet is on the meridian, as follows:

0	12 M.	2	6 P. M.	4	12 P. M.	6	6 A. M.
1	3 P. M.	3	9 P. M.	5	3 A. M.	7	9 A. M.

The tidal influence, therefore, co-operates with the maximum direct solar influence, in the atmosphere as a whole, and especially in the upper currents, at 0 and 4; in the lower atmosphere and with the surface winds, at 2 and 6. The positions of Newton's theoretical high tides (*Principia*, B. I., Prop. 66, Cor. 20) are at 1 and 5; the low tides at 3 and 7. My theoretical low barometer is synchronous with Newton's high tide; high barometer, with low tide.

The moon's influence is most marked in the heavy rains (α); least, in the frequency of rainfall (γ). The principal maximum both in frequency and amount, is near the time of full moon, when the local atmospheric

TABLE IV.

Number of Rainfalls, and amounts of heavy rains (one inch or more), at San Francisco, on Lunar days.

☾. Day.	NUMBER OF RAINFALLS.							AMOUNT OF HEAVY RAINS.						
	1849.57.		1857-64.		1864-72.		Av.	1849-57.		1857-64.		1864-72.		Av.
	No.	N.	No.	N.	No.	N.	N.	A.	N.	A.	N.	A.	N.	N.
1	8	71	16	108	14	91	89	3.26	118	1.73	84	2.38	75	92
2	12	76	17	102	16	96	91	2.89	104	4.10	95	.00	66	87
3	16	88	12	97	20	107	97	2.20	79	.00	66	4.21	81	77
4	17	96	15	99	21	109	101	1.04	61	.00	67	1.61	92	74
5	15	98	17	103	17	102	101	1.39	64	3.69	114	2.12	111	97
6	18	97	14	106	15	99	100	2.08	73	3.29	144	6.29	124	116
7	14	95	17	111	19	106	104	4.04	103	2.67	143	1.14	113	117
8	16	95	19	116	22	112	107	1.60	104	2.77	142	3.22	105	115
9	17	95	16	115	18	109	106	2.87	113	3.50	141	3.49	106	118
10	14	91	18	110	20	98	99	4.33	120	2.46	122	2.75	91	110
11	15	89	15	103	11	87	93	2.45	103	2.28	87	1.45	79	90
12	13	99	13	102	16	85	95	1.85	77	.00	64	1.05	116	88
13	22	117	18	110	15	93	106	1.21	78	1.80	80	7.76	181	116
14	23	130	17	121	19	105	118	2.46	123	2.50	123	6.09	207	154
15	21	131	21	126	20	117	124	4.79	175	1.18	166	.00	190	176
16	22	125	20	116	25	117	119	6.09	172	5.22	180	6.75	152	166
17	19	117	11	98	16	104	107	2.30	126	2.46	152	.00	118	131
18	16	118	14	89	14	98	102	.00	130	2.64	106	4.25	111	117
19	25	125	13	87	21	101	105	9.30	159	1.07	68	4.54	103	112
20	20	123	13	87	18	100	104	2.27	129	.00	60	.00	68	87
21	20	108	13	86	14	95	97	.00	83	2.99	86	1.60	49	72
22	12	91	13	87	18	97	92	3.63	78	1.06	117	1.62	55	80
23	13	88	13	89	19	98	92	2.20	72	5.16	121	1.34	66	83
24	17	99	14	89	15	93	94	.00	59	.00	98	3.08	66	72
25	20	105	14	81	15	90	93	2.54	67	2.02	90	1.02	48	67
26	16	101	8	72	17	93	89	2.38	75	2.79	93	.00	31	63
27	15	91	10	78	16	98	89	1.42	69	1.49	70	1.68	44	60
28	14	84	16	95	19	103	94	1.38	73	.00	41	.00	94	72
29	12	81	17	108	19	103	97	2.80	96	1.25	32	8.46	138	94
30	16	76	17	111	17	96	94	3.41	116	.00	48	1.67	119	98

oscillations from lunar influence are most antagonistic to solar action; the principal minimum, near the time of new moon, when the oscillations tend most strongly to reinforce solar action. These laws have such generality, that, at every station which I have hitherto examined, their influence is distinctly traceable.

Next in importance to the moon's modification of solar meteorologic influence, appears to be its modification of atmospheric pressure. I first called attention to the importance of this perturbation, in the third and seventh inferences of my paper on the "tidal rainfall of Philadelphia" (*ante* vol. x. p. 531), and showed that at Philadelphia it was more important than the direct and simple tidal energy. This modification, like the foregoing, is also traceable in all my previous lunar tables, and its prominence in the San Francisco curves (on lines 1 and 5, 3 and 7, in diagram γ, and on lines 5, 3 and 7, in α, β) is specially noticeable.

The second inference in the paper above quoted, that the tidal rainfall is, "like the ocean tides, more marked in low, than in high latitudes," is illustrated by diagrams β and δ. If further confirmation is desired, it may be found in the tables accompanying my previous discussions of different European, Asiatic and American observations.

My first prediction, that "the tidal rainfall will generally be found more strongly marked on the western shores of the several continents, than in the same latitudes on the eastern shores," is confirmed by the similarity in the amounts of average monthly fluctuation at San Francisco and Lisbon, and the smaller fluctuation at Philadelphia (β, δ). This difference should of course be greatly modified in the regions of the monsoons, and reversed in the trade-wind regions.

My third prediction, that "a certain degree of apparent opposition will be found to exist between the lunar influence upon the upper and lower cloud strata, dependent upon the normal difference of position in the tidal crests of deep and shallow fluid envelopes," is partially verified by the tendency to maxima at quadrature as well as at syzygy (2 and 6, 0 and 4, α, β, γ). The syzygy influence before new moon is manifested by the maximum after high barometer (7), but it is interrupted by the lunar intensification of solar action at new moon. If I succeed in obtaining such a record of the San Francisco winds as is necessary for the complete substantiation of the second, third and fourth predictions, I shall expect to find that the maxima at 2 and 6 are dependent upon the surface winds; those near 0 and 4 upon the upper atmospheric currents.

I still feel some doubt with regard to the certainty and character of Jupiter's influence upon the weather, but the amount of agreement between the curves for three independent periods of eight, seven and eight years (ζ), the resemblance between the curves at Lisbon and at San Francisco (η), when the origin of the ordinates is taken at opposition in one case and at conjunction in the other, and the character of the contrast between the lunar and Jovian curves at Lisbon (*ante*, p. 181), all tend to impress me with the belief, that at least one of the primary planets is

the source of important meteorological perturbations. I shall not be surprised if the Barbados records, when I receive them, furnish data for settling the question definitely in the affirmative. I can think of no more probable reason for the opposition between the Jovian curves at San Francisco and Lisbon, than the opposite directions of the ocean currents near the two coasts.

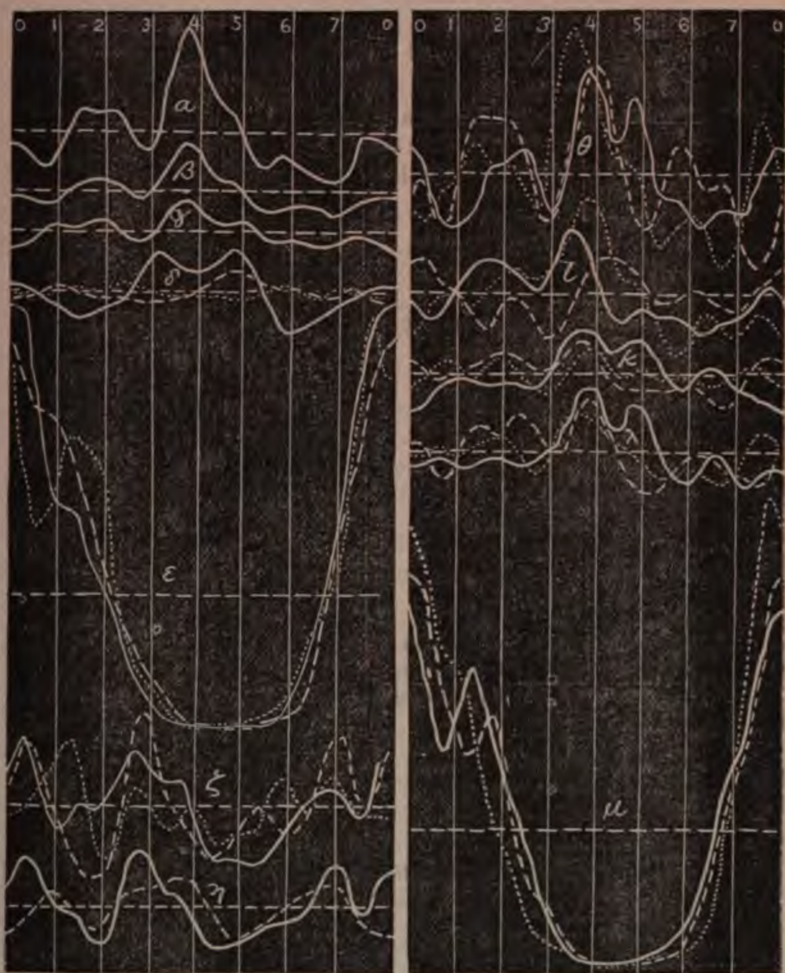
The local disturbances are evidently greater at San Francisco than at Lisbon, but in spite of them all the two sets of lunar curves at the former station, (ι, λ), each set covering three entirely distinct and independent periods, exhibit striking points of similarity, and their differences are no greater than might have reasonably been anticipated, in view of the variations in the solar curves (ε, μ). The same may be said of the monthly curves of heavy rainfall (θ) and of frequency of rain ($\varkappa$) in different periods.

Interesting special resemblances at different stations are shown at Greenwich and Philadelphia, in Fig. 4, *ante.* vol. x., p. 535; at Philadelphia, Lisbon and San Francisco, in all the lunar curves on p. 182 and in the average annual rainfall at Philadelphia on p. 181 (Table IV.) of the present volume, as well as in the accompanying curve which depicts the frequency of rain at San Francisco from 1849 to 1857 ($\varkappa$), continuous line,)* The maxima in my Philadelphia annual curve are somewhat more strongly marked than those in Schott's diagram (Pl. III., *Tables and results of the precipitation &c., in the U. S.*), on account of the different methods employed in computing the ordinates. Schott's were calculated from the monthly means (op. cit. p. 124), mine from means which cover only $\frac{1}{36}$ of a year, and therefore show the characteristic features of the curve more minutely, besides being better suited for comparison with the thirty ordinates of the lunar curve. My anticipations (Jour. of the Franklin Inst., lxiii, 205) that the San Francisco "daily records may probably furnish materials for more minute and detailed profitable investigation," having been thus satisfactorily realized, I now await the arrival of the Barbados records, with the expectation that their discussion will exhibit evidences of lunar, and possibly of planetary action, analogous to those which I have found at other stations, but still more prominent and more decisive than any that have ever hitherto been published. If there are any observations, extending over a long series of years, near the Gulf of Fonseca or on the Southwestern coast of Peru, I think they will furnish indications of the special importance of the lunar action on the barometric pressure, similar to those which I have found at Philadelphia, but that such indications will be more marked on the Peruvian coast, than on either coast of North America.

*Indications of a general maximum near full moon, with a diminution at the precise time of solar opposition, are to be found in the majority of the curves which I have computed. They afford, as I think, further confirmation of my third prediction. The surface tidal currents have their greatest Eastward velocity, and the upper atmosphere has its greatest Westward lagging, when the sun is on the upper and the moon on the lower meridian. The blending of currents is therefore peculiarly favorable for the precipitation of moisture, but the intense meridian heat appears to partially counteract the precipitation by re-evaporation.

Explanations of Diagrams.

The average rainfall in each figure is represented by the broken horizontal line. The lunar curves begin and end with the day of new moon; the solar curves with January 1st; the Jupiter curves, at conjunction for



San Francisco, at opposition for Lisbon. The vertical lines divide each cycle into octants. All the curves are for San Francisco, except in diagrams δ and η.

Diagrams of rain in lunar months.

α. Heavy rainfall. Table IV.
β. Average rainfall. Tables I, II.
γ. Frequency of rain. Table IV.
δ. Average rain at Lisbon; continuous line.
" " Philadelphia; broken line.
" " Surrey, Eng.; dotted line.

θ. Heavy rains, Table IV.
" 1849–57; continuous line.
" 1857–64; broken line.
" 1864–72; dotted line.

ι. Average rains. Table I.
Nov.–Dec.; continuous line.
Jan.–Feb.; broken line.
Mar.–Oct.; dotted line.

κ. Frequency of rains. Table IV.
1849–57; continuous line.
1857–64; broken line.
1864–72; dotted line.

λ. Average rains. Table II.
1849–57; continuous line.
1857–64; broken line.
1864–72; dotted line.

Diagrams of annual rain.

ε. Table I.
1849, '52, '55, &c.; continuous line.
1850, '53, '56, &c.; broken line.
1851, '54, '57, &c.; dotted line.

μ. Table II.
1849–57; continuous line.
1857–64; broken line.
1864–72; dotted line.

Rainfall in Synodic years of Jupiter.

ζ. Table III.
Nov.–Dec.; continuous line.
Jan.–Feb.; broken line.
Mar.–Oct.; dotted line.

η. Table III.
At San Francisco; continuous line.
" Lisbon; broken line.

SAN FRANCISCO RAINFALL.

July 1st, 1849, to June 30th, 1850.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total
1							1.01		.06				
2					1.35		.45						
3						.48							
4					.37		.39	.08					
5					1.22					.28			
6					1.12		.05	.13	.88				
7									.55				
8					1.27		1.28		.79	.05			
9				.67									
10				1.27	1.42								
11						.33							
12						1.21							
13					.76	.18	.12						
14						.10	.32						
15									.81				
16					1.15	.31							
17						.06	.16						
18						.13			.67				
19						2.08				.13			
20						.66	.17						
21						.39							
22							.07	.48	.77				
23							.95						
24							.92						
25							.52						
26						.27	.83	.34					
27								.74					
28													
29							1.10						
30				1.20									
31													
Sum				3.14	8.66	6.20	8.34	1.77	4.53	0.46			33.10

July 1st, 1850, to June 30th, 1851.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total
1													
2						.08				.28			
3										.18			
4							.11			.06			
5							.18	.02					
6							.09	.11					
7							.22						
8										.42			
9										.06			
10													
11						.26							
12			.10										
13						.35							
14			.01										
15			.15										
16										.13			
17						.36				.06			
18								.04	.23		.58		
19					.47				.40	.04	.06		
20								.12	.08		.03		
21			.07		.10			.12	.02				
22					.04				.03				
23					.11								
24					.02			.13	.03				
25									.22				
26							.12						
27									.38				
28					.13				.22				
29					.05				.21				
30									.12				
31													
Sum			0.33		0.92	1.05	0.72	0.54	1.94	1.23	0.67		7.40

SAN FRANCISCO RAIN-FALL.

July 1st, 1851, to June 30th, 1852.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total
1									.15				
2				.18			.07		.30				
3						.63			.60				
4			.04			.35	.03		.02				
5						.25			.80				
6								.05	1.20				
7			.99	.03					.75				
8					1.47				1.15				
9									.70				
10									.32				
11													
12													
13													
14									.10				
15									.04				
16					.37								
17								.02					
18					.03						.32		
19						.28							
20					.04	.14							
21						.06							
22						2.00				.17			
23						.55							
24						.60							
25						.20				.02			
26						.30							
27						.26			.25	.07			
28						.24	.16	.03					
29					.21	.30	.02	.04					
30						.82	1.30						
31						.12			.30				
Sum			1.03	0.21	2.12	7.10	0.58	0.14	6.68	0.26	0.32		18.44

July 1st, 1852, to June 30th, 1853.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total
1						.52							
2						.06					.02		
3						.19	.02						
4						.21	.04						
5						.20	.69						
6							.01						
7							1.38						
8							.81		.14				
9					.02								
10							.20				.02		
11					.40		.33			.81	.25		
12											.03		
13					.30					.36			
14					.80	.52	.18		.76				
15					.25	.03			.02				
16						.20				1.85			
17					.20	3.00				1.74			
18					.62	1.40							
19						.05				.07			
20										.11	.02		
21					1.10	.21							
22						.07		.29					
23					.12	.76		.15					
24						.11		.37			.03		
25						2.54		.34					
26								.27					
27							.25		2.85		.01		
28				.80	.30	.31	.01		.62	.08			
29					1.16	1.72			.47	.35			
30					.04	.75							
31						.05							
Sum				0.80	5.31	13.20	3.92	1.42	4.86	5.37	0.38		35.26

SAN FRANCISCO RAIN-FALL.

July 1st, 1853, to June 30th, 1854.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total
1													
2									.02				
3									.20				
4						.05		.22	.07				
5						.01		.51					
6								.16					
7													
8										.01			
9					.11	.20		.70		.01			
10				.10	.02	1.35		.52		.03			
11								.12		.20		.03	
12					.02	.11	.59	1.06	.07				
13					.08	.02	1.22		2.25				
14					.35		.27		.50				
15			.11		.20		.29		.20				
16					.22		.32						
17			.10	.02					.03			.05	
18					.14		.15						
19					.02	.10		.01	.13	.05	.02		
20						.33		.05		.43			
21								.91		.25			
22						.01	.01	1.10					
23						.02	.42	.25	.02				
24			.02				.55			.42			
25					.68		.06	.56					
26					.40			.48					
27					.04			1.26					
28						.12		.13		1.72			
29									.02				
30		.04											
31													
Sum		0.04	0.23	0.12	2.28	2.32	3.88	8.04	3.51	3.12	0.02	0.08	23.64

July 1st, 1864, to June 30th, 1865.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total
1							1.26	.09	.54	.10			
2		.01				.02	.32		.34		.03		
3			.04			.04	.80		.16				
4				.18			.15						
5							.03		.56				
6							.08		.10				
7							.32	.05	.23				
8							.29	.24	.03				
9				.22			.17						
10			.06	.21				.22		.81			
11										.38	.05		
12									.20	.17			
13				.20					.04	.50	.30		
14									.03	1.65	1.15		
15			.05							1.05			
16										.19			
17										.10			
18					.32								
19											.10		
20											.25		
21													
22				.10	.02			.15					
23				.31				.11					
24				.65									
25				.22				.25					
26				.32				1.29					
27								.52		.05			
28								1.85					
29													
30							.19		1.21				
31						.75	.06		1.20				
Sum		0.01	0.15	2.41	0.34	0.81	3.67	4.77	4.64	5.00	1.88		23.68

SAN FRANCISCO RAINFALL.

July 1st, 1855, to June 30th, 1856.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May.	June.	Total
1												.03	
2										.32			
3						.10							
4						.07		.03					
5						.17							
6						.30							
7						1.15							
8							.38						
9							1.05			.21			
10					.02	.23	1.04			.58			
11							.72			1.04			
12										.17			
13					.05	.22							
14						.05	.67		1.02				
15						.20	.32						
16													
17													
18													
19						.24		.12			.28		
20						.38	.55	.33					
21					.10	.75	.10				.08		
22					.21	.10	1.14				.40		
23					.13		.47						
24													
25													
26						.80							
27						1.00							
28					.08		1.22	.02	.05				
29							1.08		.10				
30					.08		.66		.20	.62			
31									.23				
Sum					**0.67**	**5.76**	**9.40**	**0.50**	**1.60**	**2.94**	**0.76**	**0.03**	**21.66**

July 1st, 1856, to June 30th, 1857.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May.	June.	Total
1									.13				
2							.15						
3							.44						
4							.21	.37					
5							.12	.43					
6											.01		
7				.31		.15							
8									.03				
9													
10			.02					.07			.02		
11			.05			.28		.05					
12						.21		.31					
13								.53					
14				.01		.04		1.27					
15					.16	.03		1.30					
16				.02	.06		.24	.84					
17				.03	.20	.45	1.19						
18							.10	.04					
19								.04					
20					.90								
21					.17				.18				
22					.70				.03				
23					2	.20							
24				.08	.2	.24		.87	.29				
25								1.17					
26	.02							.85					
27						.20		.45	.36				
28					.06				.47				
29					.32	.08						.12	
30						.48					.02		
31						1.39			.13		.05		
Sum	0.02		0.07	0.45	2.79	3.75	2.45	**8.59**	**1.62**		**0.10**	**0.12**	**19.96**

SAN FRANCISCO RAINFALL.

July 1st, 1857, to June 30th, 1858.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total
1										.42			
2					.10								
3					.35								
4					.88	.15				.27			
5					.81	.20							
6				.17		.26							
7				.44			.03	.03		.72			
8				.32						.14			
9						.22							
10		.03				.43	.25						
11						1.68	.37						
12						.22	.40		.62				
13							.51	.06					
14								.80					
15								.44					
16								.41	.17				
17								.25	.04				
18												.05	
19								.20			.23		
20							.83	.15			.06		
21							.55				.05		
22							1.42						
23													
24					.15	.98			.40				
25					.49								
26					.14				.37				
27					.17				1.80				
28		.02			.04				.60				
29					.33				1.65				
30					.05								
31													
Sum		0.05		0.93	3.01	4.14	4.36	1.83	5.55	1.55	0.34	0.05	21.81

July 1st, 1858, to June 30th, 1859.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total
1								.24			.38		
2											1.07		
3									.21				
4						.07			.29				
5						.27							
6								.16					
7								.08	.20				
8								.54	.20	.13			
9								.11					
10						1.80		.12		.03			
11						1.02		.62		.02			
12						.08		.78					
13								.14					
14		.04				.17							
15								.34					
16								.14					
17						.06		1.04					
18													
19					.27								
20				.30	.20				.15				
21				2.06	.14	.05			1.07				
22					.04				.73		.06		
23				.12		.42		.13			.04		
24				.26		.64		.34					
25								.12					
26		.12			.04	.28		.08	.03				
27	.02					1.04	.05	1.11	.04				
28	.03					.20	.21	.23					
29									.03				
30							.17		.07				
31						.04	.85			.09			
Sum	0.05	0.16		2.74	0.69	6.14	1.28	6.32	3.02	0.27	1.55		22.22

SAN FRANCISCO RAINFALL.

July 1st, 1859, to June 30th, 1860.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May.	June.	Total
1							.08		.40	.49	.12		
2					.06		.07				.62		
3		.02			.36		.24			.05	.43		
4					.90	.04				1.32	.12		
5					.84		.21		.37	.65			
6							.56		.08	.06		.07	
7							.22	.60		.04			
8							.23			.44			
9					.92								
10					.80				.13				
11					.13						.17		
12								.10	.03				
13								.43					
14													
15			.03						.10				
16								.04	.17				
17					.07			.17					
18								.14			.39		
19										.09			
20													
21					.14								
22					.23		.03		.39		.35		
23				.05	.25	.21			.11		.28		
24					.31	.63					.04		
25					1.73	.38					.28		
26					.51	.21					.06		
27						.10			.05				
28									.90			.02	
29								.12	.62				
30													
31					.03				.69				
Sum		0.02	0.03	0.05	7.28	1.57	1.64	1.60	3.99	3.14	2.86	0.09	22.27

July 1st, 1860, to June 30th, 1861.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May.	June.	Total
1						.02	.21						
2										.16			
3				.01						.15	.10		
4				.12			1.03			.03			
5				.08			.49					.04	
6				.01		.04	.23						
7						.13		.06					
8													
9								.12					
10	.21					.02		.14					
11					.21	.13		2.02					
12					.35	.07						.04	
13													
14						.87							
15						.23	.03						
16						.78							
17				.04		.04							
18						.26							
19				.17		.27	.14						
20				.08		.21	.22				.65		
21						.15		.21			.25		
22						.58							
23						1.03	.12	.08	.79				
24				.12		.77		.10	.07	.17			
25						.63		.99	.04				
26						.13			2.53				
27				.03		.07			.40				
28				.11	.02				.04				
29				.04					.18				
30				.10					.03				
31						.23							
Sum	0.21			0.91	0.58	6.16	2.47	3.72	4 08	0.51	1 00	0.08	19.72

SAN FRANCISCO RAIN-FALL.

July 1st, 1861, to June 30th, 1862.

Day.	July	Aug	Sept	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May.	June.	Total
1						.05				.11	.02		
2			.02					.79		.13	.56		
3						.07				.07			
4													
5							2.67	.04		.01			
6						1.02	1.49						
7						.29			.02				
8						1.65	1.35			.09			
9						.18	3.50		.01	.17			
10					.27		2.46		.47				
11							1.25		.57	.01	.03	.05	
12					.74				.18		.11		
13					.29		0.22			.02			
14					.05				.25	.12			
15					.08		.49		.11				
16					.39	.01	2.46		.12				
17					.22		2.64						
18							.52				.02		
19					.56		.72	.44					
20							1.69						
21							.55	2.09					
22						.03	1.00	.80					
23						1.06		.84					
24						.56		.33					
25								1.49					
26					.48	2.02		.38					
27					.60	.23	.04	.33					
28						.17			.07				
29					.08	.70	.76		.20				
30					.34	1.25	.55		.20				
31						.25							
Sum			0.02		4.10	9.54	24.36	7.53	2.20	0.73	0.74	0.05	49.27

July 1st, 1862, to June 30th, 1863.

Day.	July	Aug	Sept	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May.	June.	Total
1							.27						
2													
3							.12						
4							.71						
5							.46	.44					
6					.11			.16					
7					.02				.05				
8								.11		.19			
9						.19							
10					.02								
11							.15	.16					
12								.71					
13										.12			
14								.11		.10			
15										.38			
16								.40		.32			
17								.58	.16				
18						.12		.47	.19		.14		
19						.05	.74		.11		.09		
20						.32	.36		.56	.24			
21						1.01		.05		.10			
22						.17	.76						
23						.14	.06						
24									.04				
25									.07				
26									.88	.12			
27										.04			
28													
20				.02									
30				.38		.22							
31						.13							
Sum				0.40	0.15	2.35	3.63	3.19	2.06	1.61	0.23		13.62

SAN FRANCISCO RAIN-FALL.

July 1st, 1863, to June 30th, 1864.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May.	June.	Total
1										.91			
2						.33	.12						
3										.35			
4										.23			
5							.39						
6													
7													
8													
9						.15							
10						.05					.01		
11					.05	.02					.10		
12					.07								
13						.27					.01		
14					.87						.11		
15					.92		.14		.03				
16					.64								
17									.04		.55		
18									.89				
19													
20			.03						.02				
21						.37							
22													
23						.52							
24						.09							
25													
26										.08			
27									.06				
28									.14				
29							.37		.09				
30									.07				
31							.81		.18				
Sum			0.03		2,55	1,80	1.83		1.52	1.57	0.78		10.08

July 1st, 1864, to June 30th 1865.

Day.	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May.	June.	Total
1							.51						
2						.33							
3						.13			.21				
4						.03			.38				
5						.04							
6						.92	.06			.21			
7			.01							.62			
8													
9										.11			
10						.01							
11						1.05							
12						2.56			.07				
13						.99		.30					
14								.10					
15					.14	.04		.08					
16						.27		.12					
17													
18							.07	.40			.45		
19								.24	.08		.18		
20													
21													
22		.11											
23		.03			.05	.38							
24		.07		.02			.07						
25					.48	.47	.88						
26				.05	3.98	.81	.38						
27				.06	.42		.74	.05					
28					.44	.02	.91	.05					
29					.50	.04							
30					.67	.30							
31						.52	1.50						
Sum		0.21	0.01	0.13	6.68	8 91	5.14	1.34	0.74	0.94	0.63		24.73

SAN FRANCISCO RAINFALL.

July 1st, 1865, to June 30th, 1866.

Day.	July	Aug	Sept	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total
1						.01		.36					
2						.01		.16					
3								.43					
4								.19					
5							.30	.22	.02				
6							.19		.21				
7				.03			.41						
8				.07		.04	1.51		.66			.04	
9								.16	.30				
10							.40						
11							.46						
12							.60	.06					
13					.18	.06	.60						
14					.37								
15													
16					.07		.23						
17					1.03		2.17		.02				
18					.27				.21				
19					.06		.11		.41				
20					.06		2.22		.23				
21					.63		1.14				.06		
22					1.12	.04	.15				.22		
23						.15	.08						
24			.06			.25	.31						
25				.01					.36		1.05		
26			.18			.02					.01		
27								.07			.05		
28								.47			.07		
29									.02	.12			
30				.15	.40				.11				
31									.49				
Sum			0.24	0.26	4.19	0.58	10.68	2.12	3.04	0.12	1.46	0.04	22.93

July 1st, 1866 to June 30th, 1867.

Day.	July	Aug	Sept	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total
1						.53			.17	.32			
2					.68		.03		.16	.15			
3					.25	.13							
4					.14		.18						
5					.31		.65			.40			
6			.07				.51			.15			
7													
8					.07				.40				
9										.02			
10										.67			
11						.53	.11			.50			
12						.01	.75			.15			
13													
14							.05						
15			.04			.63							
16					.26	.43							
17									.16				
18						.95		.49					
19					.02	4.28	.23	.15					
20						3.62	.18	2.12					
21						.64	.58	2.22	.34				
22						.31	.17	.30					
23							.40						
24					.38	.06	.35						
25					.29	.71		.08					
26					.28	.56	.78	.14					
27						.32		1.02					
28						.63		.68					
29					.14	.40							
30					.53	.42	.19		.05				
31									.30				
Sum			0.11		3.35	15.16	5.16	7.20	1.58	2.36			34.92

SAN FRANCISCO RAINFALL.

July 1st, 1867, to June 30th, 1868.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May.	June.	Total
1						·02	.93		.56			.01	
2						.18	.33		.20				
3							.12		1.55	.10			
4							.15		.55				
5				.20	.62								
6					.75								
7						.15		.06		.20			
8						.55	.66						
9						.24				.38			
10						.33				.30			
11							.12		.19	.70			
12							.87			.47	.01	.05	
13							.43		.56	.06			
14			.04						.44	.04			
15									.14				
16						.04							
17						1.62	.12						
18						.69	.41				.02		
19					.79		.43						
20						.48	.64		.16				
21					.75	.84		.64	1.05				
22						1.68	1.08	.54	.90			.08	
23						.72	.99	.14				.09	
24					.44	.08	.84	.86					
25					.06	1.35	.36	.69					
26							1.02	1.61					
27								1.02					
28								.37					
29						.06		.20					
30						.21				.06			
31						1.45							
Sum			0.04	0.20	3 41	10.69	9.50	6.13	6.30	2.31	0.03	0.23	38 84

July 1st, 1868, to June 30th, 1869.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May.	June.	Total
1				.06			1.28						
2				.08			.53	.44					
3								.30					
4				.01	05	.01							
5													
6													
7							.10	.20		.28			
8								.82					
9								.32					
10							.01	1.67					
11							.07	.15					
12									.05				
13									.08				
14							.08		.10			.02	
15									·14				
16									.63	.45			
17						.05			.55	.69			
18					.30	.55			.18	.68			
19					.64				.48	.09	.06		
20									.67				
21						.07							
22						.18	.15				.02		
23						1.20	1 45						
24						.29	.19		.01				
25					.08	.47	.25						
26						.92	.20		.10				
27							.15						
28							.54						
29					.11	.18	1.10		.15				
30						.32	.25						
31						.10							
Sum				0.15	1.18	4.34	6.35	3.90	3.14	2.19	0.08	0.02	21.35

SAN FRANCISCO RAINFALL.

July 1st, 1869, to June 30th, 1870.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total
1			.12										
2										.48			
3										.21	.02		
4										.09			
5													
6					.14								
7						.41							
8						1.10				.01			
9								.41					
10					.65	.13	.09	.02	.02				
11					.20	.14	.11		.14	.16			
12					.05		.14	.14	.18	.58			
13					.05		.35						
14							.53	.11					
15							.31	.34					
16									.22				
17									1.05				
18				.02			.76						
19				.17			1.03	.08			.18		
20				.36			.27	.86					
21				.74				.25					
22						.22	.30	.90					
23						.46		1.57	.27				
24						.51		.10					
25						1.34							
26													
27					.04								
28					.06								
29													
30									.01				
31													
Sum			0.12	1.29	1.19	4.31	3.89	4.78	2.00	1.53	0.20		19.31

July 1st, 1870, to June 30th, 1871.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total
1						.59							
2						.57							
3										.06			
4					.01			.37					
5						1.42				1.47			
6					.02	.12		.12	.26				
7					.22	.32							
8								.02					
9							.42						
10							.82						
11													
12									.01				
13						.09		.14					
14						.27		.13					
15								.67			.04		
16									.08	.29			
17							.21		.08	.11			
18							.78						
19									.36				
20								.72					
21								1.02					
22							.28	.28	.13				
23							.62	.29	.37				
24													
25													
26											.01		
27													
28							.44				.16		
29					.18								
30			.03										
31													
Sum			0.03		0.43	3.38	3.07	3.76	1.29	1.93	0.21		14.10

SAN FRANCISCO RAINFALL.

July 1st, 1871, to June 30th, 1872.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May.	June.	Total
1								.02	.14				
2						.16		.06					
3					.19		.86	.14					
4								.01	.17			.01	
5							.17		.50				
6							.10						
7							.18	.33					
8							2.35	.89	.11				
9					.03		.34	.82	.06				
10								.21					
11							.11	.28	.33				
12							.02		.13	.05			
13					.02		.02						
14					.18			.10					
15					.22			.24		.35			
16								.29		.43			
17			.01			.63		.28		.08			
18						3.22		.02					
19						3.49				.01			
20						.62							
21						.93		.61					
22						.32		.44	.02				
23						3.48		.76					
24				.02	.35			.41			.03		
25								.16					
26					1.67	.15				.16			
27			.02	.09	.13	.74		.90	.04	.02			
28					.93	.23							
29						1.04							
30						.13					.02		
31						1.60	.07		.14		.11		
Sum			0.03	0.11	3.72	16.74	4.22	6.97	1.64	1.10	0.16	0.01	34.70

ON THE DENTITION OF METALOPHODON.

By Edward D. Cope.

(*Read before the American Philosophical Society, September 20, 1872.*)

This discovery of a second species allied to *Bathmodon*, Cope, represented by more complete remains of dentition than that on which that genus was originally established (*B. radians*), renders it possible to enlarge our knowledge of its characters.

It may be premised that the new species may belong to the group *Loxolophodon*, and, as its characters differ from those of the large species *Eobasileus cornutus*, *furcatus* and *pressicornis*, I must retain the last named genus with characters ascribed in my last paper to the former, and withdraw the species from the former, to which I at that time referred them. It appears that this name, used first for a section of *Bathmodon*, was, perhaps, based on mandibular teeth alone, which in *Metalophodon*, differ remarkably from the maxillaries. The cranium of the new species to be described was so decayed as to be irrecoverable, but the teeth obtained were in place, and in close proximity, so that there can be no reasonable doubt that they belong to the same animal.

The species differ considerably from the *B. radians*. The most prominent are: first, the failure of the lateral or straight limbs of the

crescent of the tooth-crown to meet at the apex, in the molars proper; second, the presence of two lobed premolars only, the three lobed found n *Bathmodon* not being represented in any series. The first character appears to me to be of generic importance, hence the name applied to it at the head of this article. It may yet prove to be *Loxolophodon*, as no generic character distinguishes the inferior molars of the two. It remains however, to determine whether that name applies to *Bathmodon*, or a genus different from it, as the present. In the meantime the new species may be called *Metalophodon armatus*. It is as large as the Indian *Rhinoceros*, or perhaps larger.

The *incisors* are well developed, those of the premaxillary subequal in size. The crown has a convex cutting edge and flat inner face. The outer face is convex. In some the inner face is more concave, and is bounded by a cingulum next the root.

The *premolars* present a single external crescent of acuminate outline, and a smaller, more transverse one, within. A cingulum bounds the crown fore and aft, but is wanting at both base and apex of the triangular base. In the more posterior the crescent is more open, and the crown less transverse.

The *molars* present an increase in transverse extent of the external crescent, and the interior one is wanting. In the posterior two the anterior ridge curves round at the apex, but is separated by a considerable interruption from the posterior. The latter is shortened, and terminates externally in a conic tubercle, which approaches the outer extremity of the anterior ridge. In the last molar the posterior ridge is shorter, nearly straight, and terminating in a cone at each extremity.

The *canine* is damaged, but was of large size, amounting in one or the other of the jaws to a tusk. The probably superior is compressed, with acute edges. The inner face gently convex, the outer more strongly so, with an acute ridge on its anterior convexity, inclosing an open groove, with the interior cutting edge. This surface of the dentine when exposed has a transversely wrinkled character, but no trace of engine-turning in the fractures.

In the *mandible*, premolar and molar teeth are recognizable; the character of the incisors remaining uncertain. As usual in ungulates, they possess a relatively smaller transverse diameter than do the corresponding teeth of the maxillary. They change very materially in form from the front to the terminus of the series, and in connection with the superior molars, are very instructive as to the genetic connection of different types of dentition.

The pecularity of the *premolars* consists in the fact that besides the single external crescent exhibited by those of the upper jaw, they have a rudimental second one in the position it should occupy in corresponding teeth of *Palæosyops*. The inner border of the crown is convex, and extends from apex to apex of the crescents. There are no cingula to these teeth. The rudimental crescent diminishes anteriorly, its angle

becoming first obtuse, and then disappearing. Posteriorly the reverse process takes place, and proportions increase. But in the last *molars* they do not assume the proportions seen in *Palæotherium* and allied forms. They increase in the elevation of corresponding ridges of the crescents, and decrease in the others, so that the resultant form is nearly like that of *Dinotherium* or perhaps *Lophiodon*. The outer ridge of one crescent appears as a cingulum, which sinks to the base of the crown from the apex. This is rudimental in the genera just mentioned. The corresponding bounding ridge of the other crescent is reduced to a rudiment extending diagonally across the valley between the remaining crests, as is seen in not a few genera of the Eocene.

We have thus an explanation of the heretofore obscure question as to the origin of the crescent-bearing tooth of the Artiodactyles. From the two crested type of *Tapirus*, the two-angled form develŏpes itself by the growth of the cingulum and diagonal crest just described. This is seen completed in *Palæosyops*. The elevation of the ridges and deepening of the intervening valleys, would result in the ordinary Ruminant type. The same process increasing transverse crests only, derives the *Mastodont* from the *Tapiroid* form, and the deepening of the valleys of this, again results in *Elephas*.

In comparison with *Bathmodon semicinctus*, Cope, the crowns of the premolars are of similar size, but considerably less elevated.

The measurements cannot be given with exactitude, but are approximately as follows: Superior incisor crown, width. 75 inch; elevation .60 inch. Canine 1.25 inches from apex, inner face .75 inch. Premolar length. 76, width 1.1 inch. Molar length crown 1.1 inch, width 1.25 inch. Inferior premolar, length of crown 1 inch, width .75 inch. Posterior molar, length 1.30 inch, width .9 inch. The crests of the last mentioned are quite elevated, one more than the other; the lower with a strong cingulum at the base, which rises to what is homologous with the base of a triangle, or outwards; none on the inner aspect of the base of the crown. The cingula of the superior molars are only anterior and posterior.

This large ungulate was found in a stratum below those of the Green River Group of Hayden, or in the lower beds of that series, near Black Buttes, Wyoming. Obtained by the Geological Survey under direction of Dr. F. V. Hayden.

In a line of banks or low bluffs, immediately below that in which the *Metalophodon* was found, dermal scutes of a small crocodilian are abundant. The discovery of the greater part of a cranium of one of these enables me to point out the existence of a species of Alligator of still smaller size than the smallest of the Caimans at present inhabiting South America. This species, which I call ALLIGATOR HETERODON, possess several peculiarities. The anterior and posterior teeth differ exceedingly in shape; the former are flattened, sharp-edged, and slightly incurved; the edges not serrate. Those of the premaxillary bone are subequal in size, while one behind the middle of the maxillary is larger

than the rest. The posterior teeth have short, very obtuse crowns with elliptic fore and aft outline. They resemble some forms seen in Pycnodont fishes, and are closely striate to a line on the apex. The upper surface of the cranium is pitted, the frontal and parietal bones, with large, deep, and closely placed concavities. The former is perfectly plane, and the latter is wide. The squamosal arch is also wide, and the crotaphite foramina are large and open. The dermal scuta are very large for the size of the animal, and were not united by suture. They are keelless, and deeply pitted, with smooth margins.

The vertebral centra found with other specimens are round. The coössified neural arches indicate the adult age of the animal.

MEASUREMENTS.

		M.
Height crown premaxillary tooth		.004
Width " " at base		.0035
Long diameter crown of a maxillary		.005
Short " " "		.0035
Width parietal		.009
Width frontal	posterior	.020
	interorbital	.010
Width molar below eye		.008

The variation in the form of the teeth is a slight exaggeration of that seen in the dentition of various species of crocodilians.

Stated Meeting, Oct. 4th, 1872.

Present, 20 members.

Vice-President, Mr. Fraley, in the chair.

A letter, accepting membership, was received from the Rev. S. H. Nichols, dated 415 South Fifteenth Street, Philadelphia, September 26th, 1872.

An engraved portrait of William Smith, D.D., first Provost of the College of Philadelphia, was presented by Mr. Horace W. Smith.

A circular letter, announcing the death of Signor Felice Finzi, dated Firenze, 4th September, 1872, was received from his relatives.

A letter of envoy and acknowledgment (Proc. 81 to 85) was received from the Geological Society of St. Petersburg.

Donations for the library were received from the Revue Politique; the Meteorological Committee of the London R.

S.; London Nature, Old and New; American Academy of Sciences; American Oriental Society; Prof. O. C. Marsh; M. Alph. Loubat; the Franklin Institute; Academy of Natural Sciences; Journal of Pharmacy and Penn Monthly, of Philadelphia, and the Petroleum Monthly.

An obituary notice of Mr. Eckfeldt, by Mr. Dubois, was read by appointment by Mr. Patterson.

The death of Mr. Ralph Ingersoll, of Connecticut, a member of this Society, August 25th, aged 83, was announced by the Secretary.

Mr. Lyman offered for publication in the Transactions, a paper and map of his researches into the geology of the Staley's Creek Coal and Iron region of Virginia, which he described summarily. On motion, they were referred to a committee, consisting of Prof. J. F. Frazer, Mr. Lesley, and Professor P. Frazer, Jr.

Pending nominations, Nos. 697 to 702, were read, and new nominations, Nos. 703 to 705.

On motion, the West Virginia University, at Morgantown, was ordered to be placed on the list of correspondents to receive the Proceedings.

On motion of Mr. Price, it was resolved that the Curators be authorized to deposit the arm-chair, now in posession of the Society, one of those used by members of the Continental Congress, in the Hall of Independence: provided the authorities of the City of Philadelphia will agree, by Ordinance, to return it to the Society, whenever so requested by it.

Dr. Elder asked and received permission to deposit in the Hall of the Society a chair, left in his care by Mr. Washington, who fell at Vicksburg; said chair having been occupied by Judge Bushrod Washington, presiding in the Circuit Court of the United States.

And the meeting was adjourned.

Obituary Notice of Mr. Jacob R. Eckfeldt.

By Mr. Dubois.

(*Read before the American Philosophical Society, Oct. 4th*, 1872.)

Jacob R. Eckfeldt, late Assayer of the Mint, was the son of Adam and Margaretta Eckfeldt, and was born in Philadelphia March —, 1803. He was, therefore, in his seventieth year, at the time of decease, August 9th, 1872.

He early developed a studious mind, and a fondness for solid information, especially in the domains of physical and mechanical science. He was mainly educated at the classical academy of Dr. Wylie and Mr. Engles, celebrated in those days.

When he was grown up, and old enough to engage in business, he was placed in Mr. Greiner's Cotton Mill, at Trenton, as a subordinate manager, where he continued for several years, until that enterprise proved unsuccessful. After that, he was employed by Mr. Cloud, then Melter and Refiner of the Mint, to attend to the parting room.

In the Spring of 1832, Mr. John Richardson, who had been Assayer about one year, and did not find the employment congenial to his tastes (withal a man of good parts and highly esteemed), informed Mr. Eckfeldt that he intended to resign, and wished him to prepare to take the place. Mr. E. shrank from this responsibility and declined. But some of his friends who had influence with President Jackson presented his name with a strong recommendation and he was appointed without being asked as to his party preferences. This occurred on the 30th of April, 1832. He has therefore held the office over forty years.

When he entered upon the work, he had to encounter some embarrassments. The apparatus was old-fashioned, and not calculated for nice results. The silver assay had been well performed, without going to a close figure, for many years; but gold was little known in the country or at the Mint, and it is not surprising that its assay was incorrectly performed. Add to this, there was the coarse and cumbrous nomenclature, brought from the old country, of carats and grains for gold fineness, and so many grains to the pound for silver fineness.

Close upon all this, that is to say, in June, 1834, came the celebrated reduction in the standards of our gold coin, one of the chief measures of the Jackson administration. This changed gold from a curiosity to a currency; bullion and foreign coin flowed to the mint, and accuracy of assay was more than ever needful. Mr. Eckfeldt was equal to the emergency; and resolutely introduced reforms, which, at first, made the older officers stand in doubt. At this crisis he was taken down with small-pox; and shortly after, his valued foreman also. Both, however, recovered.

In those days, about the time the new mint edifice on Chestnut street was finishing, Mr. Peale was sent to London and Paris to observe the methods of assaying and refining, and to procure a new apparatus. We were thus supplied with French beams, weights, and cupel furnaces, and

with the appliances of Gay-Lussac's humid assay, and the printed details of the process. Soon after, Mr. Saxton, famous for his skill in constructing balances and other delicate instruments, returned from a long schooling in that line in London, and was employed in the Mint. Thus furnished, Mr. Eckfeldt felt himself "set up," and able to compete with the foreign assayers, and if he was ever more precise, it was because he disregarded certain allowances which had become a time-honored custom.

A large importation of fine gold bars from France, known as the French Indemnity, and which came because President Jackson declared he "would submit to nothing that was wrong," gave a fine opportunity for testing and comparing foreign assays; and it was generally found that these bars were somewhat below the alleged fineness. Still the deficit was inconsiderable; but it is characteristic of French gold coin, as well as bars.

It is not surprising, that he felt at first the inconvenience of passing from one form of nomenclature to another, though to a better one. A friend remarks, "I recall conversations with Mr. Eckfeldt, showing how seriously he felt the revolution. He would *think* in carats, and *report* in decimals. And I often recur to this as illustrating the kind of difficulties which would arise in case of a decimalising of weights and measures."

For some years prior to 1842, Mr. Eckfeldt and his assistant, in addition to their ordinary duties, engaged in the preparation of an original and comprehensive work on the Coins of all Nations; on the Varieties of Gold and Silver Bullion; on Counterfeit Coins, and on other subjects related thereto. This was published in 1842, and has long been regarded as a standard authority. In 1850, they issued a supplementary smaller work, and again in 1852.

As the United States increased in commerce, wealth and population, the Mint of course increased in work. In particular, Mexican dollars came in great quantities for recoinage. Not only were our vaults full, but our entries and corridors were at times crowded with rows of kegs. Every day, for years, we had the constant task of sixteen melts of silver ingots to melt and assay; and it was a great advantage and satisfaction to be supplied with the *humid* apparatus.

The success of gold mining in our Southern States, and the increasing commerce of New Orleans, gave rise to the establishment of three branch mints at the South, in 1837; and it devolved upon Mr. Eckfeldt to become schoolmaster, and educate the three assayers appointed for those places. The same had to be done again at a later date for other mints and assay offices.

In December, 1848, came the first lot of gold grains from California; and with the opening of the next year the tide set in most powerfully. I shall not here speak of this great turning-point in metallic currency any further than as it affected the mint, or rather the labor which it laid upon Mr. Eckfeldt and his department. As is well known, the lots were numerous, and the aggregate amount was enormous. Instead of making

gold assays by dozens, we had to go through with hundreds, every day following the arrival of each steamer. We procured young men as operators in the weigh-room and additional workmen in the laboratory; and in spite of all the help we were all overworked. Here let me say that the persons who have been educated by Mr. Eckfeldt to this profession have done credit to the selection that was made, not only by skill, diligence, and good character while here, but wherever they are now scattered to other mints and assay offices, or to different pursuits. No doubt they receive with profound sorrow the tidings of the decease of their instructor.

The gold pressure continued for about five years, when it was relieved by the creation of a government assay office in New York, and a branch mint at San Francisco. But directly sequent to this came the change of standard in silver coin, causing an immense recoinage in small pieces. Thus our daily assays continued to count by hundreds. This lasted for some years. When it began to slacken off, a law was passed for calling in the large copper coins and issuing in their stead pieces of copper-nickel alloy of much smaller size.

The analysis of Nickel alloys was not well laid down in the books, and the European or other assays which came with purchased lots showed an incorrect determination. Mr. Eckfeldt was therefore obliged to study out and perfect this assay, which is more tedious and laborious, though of less consequence, than the assay of the precious metals.

But it was his habit to be as scrupulous in minor matters as in major; and after the routine was well settled it went on with the same clockwork regularity as the other branches of assaying. I need not say that this nickel coinage imposed another heavy pressure upon the mint for years.

After this came the substitution of the Bronze alloy; and this called for another process of assay, and brought us a great deal of work.

I thus hastily review this sequence of gold, silver, nickel, and bronze, not only as an interesting part of Mint History, but to show the varied and abundant services of the untiring, energetic Principal Assayer, and the masterly skill with which he met every obligation.

His nervous system, naturally not one of repose, was a good deal impaired by the cares and labors of the first period just reviewed, and in 1853 he had to seek relief by travelling southward. This had a beneficial effect, but from that time onward, although he continued to be very active, there was a marked deterioration of health. Early in the Summer of 1870 he had a serious spell of illness, in which an affection of the heart was developed. This, by degrees, culminated in a dropsical state of the system, and on the 26th day of April, 1872, he was at the mint for the last time.

I would not undertake to define his various traits of character, professional or personal; but a few remarks in that way may be in place.

In every character we may observe apparent or real opposites; and in respect to Mr. Eckfeldt, there were two notable instances.

First, he was not ready in the use of language. There was wealth of thought, but not freedom of expression. This was always to some extent his embarrassment. If, with his stores of general and scientific knowledge, he had also possessed the powers of a speaker or writer, he would have made a larger impression. And yet he was communicative and sociable habitually. In his daily rides in the car, part-way to his house in the country, he was glad to find those with whom he could converse along the road. This is only an instance of his social temper, at home and abroad.

Again, it cannot be said that he made what might be considered inventions or discoveries of new processes. Inventors are really few; and they are generally much indebted to those who come after them and improve upon them. And yet his skill and success as an Assayer and Analyst largely consisted in his power of finding out what was defective or erroneous, and in applying the proper remedy. It often seemed that what was a puzzle to others was to him a matter of quick insight.

In the assays of certain complex alloys, and of low grades of gold and silver, he contrived various methods which are not in print, but which are of great use in the daily manipulations.

And here I may state that he not only introduced great accuracy and precision in the assays, but carried special investigations to a delicacy almost incredible. This was partly to be credited to the progressive improvement in assay balances, by which, after discarding the old silken cords, we had Deleuil's beam with steel stirrups; then Saxton's palladium beam with drop supports, then the more sensitive and more complicated Oertling, and at last the simple and complete Becker. So that, instead of weighing to a thousandth of the normal weight as formerly, we now have indications to the tenth of a thousandth, or even less.

If, therefore, curiosity or the promotion of science led him to inquire how much or rather how little silver there was in a certain kind of lead or gold in an ordinary brick or pile of gravel, he would begin with a pretty large sample, then carefully concentrate the precious metals, if any, and finally bring his visible speck to the balance, to determine a proportion in millionth parts. Only lately he found in a bar of Spanish lead, which is remarkably free from silver, the amount of one-third of an ounce of silver, in a ton of lead,—and much interest was excited by a publication some years ago, both in this country and across the Atlantic, of his experiment upon the brick-clay which underlies our city. Taking two samples from the center of the town and the suburbs he found they contained gold at the rate of nearly 12 grains (say fifty cents) to the ton of clay in its ordinary moisture. Other experiments went to prove the very general diffusion of gold, in infinitesimal proportions.

Some analysts, through want of exactitude, or for the pleasure of making a sensation, may produce very curious results; but Mr. Eckfeldt was conscientious, I may say, nervously scrupulous, about stating anything he was not sure of. Partly for that reason, partly for the very love

of work, he was laborious to a fault, all his life long. It can hardly be said to have shortened his days, for he well nigh attained to the limit and double the average of human life.

Although he did not take the same interest in rare and curious coins that his father did, and was not a student of numismatics, yet he had a cultivated taste in this way, and a fine appreciation of the principles and art by which a perfect piece is made.

He was baptized and confirmed in the Lutheran Church, and afterwards united with the Presbyterian Church in Ninth St., near his father's house. He was soon elected to the Eldership, and he was no honorary or nominal Elder, but fulfilled the duties of the office, and was valued for his solid judgment. He was moreover active in the Sunday-school, the Bible Society, and other modes of benevolent operation. Some years after he became a member and elder in the Arch street Church; and since his residence in the country has belonged to Marple Church, in Delaware county.

He was elected a member of this Society in January, 1843.

He was a man of feeling, as well as of principle; affectionate, as well as exact. He made new friends and cherished old ones. This disposition even increased with his years, and was not diminished when his mind had lost its power. There were many proofs of this, which may not here be repeated. But the writer may be excused for stating an instance in his own experience. As he stood by the bedside, one of the family asked Mr. Eckfeldt if he knew who it was. The very question started an agitation which was almost convulsive, and with extreme difficulty he said, "Do—you—suppose— Do—you—suppose——" and could say no more. But it was easy to supply the rest. "Do you suppose I should not know him, having been with him for thirty-nine years?"

In harmony with his religious sentiments he was a man of pure speech, of upright dealing, of modest demeanor, of benevolent heart, and of patriotic spirit. How could any one fail to recognize the advantage of daily association for many years with such a man?

I shall venture only one line as to a kind of dying testimony which we all value. In the few last weeks his mind was much clouded, and his speech nearly cut off, by the force of disease. Yet in a clear interval he was overheard to express his unreserved self-dedication to his Lord and Saviour.

The concluding remark may be offered that the Mint has sustained a great loss in losing so much skill, so much experience, so much exactness, such probity, and superiority to reproach, as were concentered in this one man. We cherish the remembrance of his name and services which impart dignity and character to the history of this Institution.

Immediately after the fact of his decease meetings were held at the Mint in Philadelphia and at the branch Mint in San Francisco, at which addresses were made by the present director of the Mint and two former directors, and other gentlemen, expressive of strong regard and esteem

both official and personal; and resolutions of the same tenor were unanimously adopted by the officers and workmen.

To this I will only add in conclusion, the unsought testimony, just received, of a gentleman who, after a service of fifty years in the Royal Mint at London, lately retired from the post of Queen's Assayer, which he had filled with great ability.

"I have to express my unfeigned regret at this loss to science, and especially our branch of it. I was not personally known to Mr. Eckfeldt; but I can say, his name and his works will live forever in the wide world. I sympathize in the loss his relations will have to sustain."

Stated Meeting, Oct. 18th, 1872.

Present, 17 members.

Dr. Emerson in the chair.

Dr. Agnew and Mr. Coleman Sellers, newly elected members, were introduced to the presiding officer, and took their seats.

Letters accepting membership were received from Mr. Coleman Sellers, dated Philadelphia, October 12th, and from Dr. R. J. Levis, dated Arch and Thirteenth Streets, Philadelphia, October 14th, 1872.

A letter of envoy was received from the Imperial Academy at Vienna, dated May 8th, 1872.

Letters acknowledging the receipt of publications were received from the Asiatic Society of Bengal, June 15th, 1872 (83 to 85, XIV. i.); the Imp. Academy, Vienna, November 7th, 1871 (83, 85, 86, XIV. i, ii.); the Zoological Society, London, 87 Hanover Square, September 30th, 1872 (83 to 88, XIV. i. and iii.); the Royal Soc. Edinburgh, March 18th, 1872 (82); the Lyceum of N. H., New York, October 7th, 1872, (88). the University of Virginia, October 7th, 1872 (88); the American Academy, Boston, October 8th, 1872 (88); the Maryland Historical Society, Baltimore, October 7th, 1872 (88); the University of the City of New York, October 10th, 1872 (88); the New Jersey Historical Society, Newark, October 8th, 1872 (88); the Maine Historical Society (88), announcing also the decease of Mr. Ballard; the Essex Institute, Salem, October 11th, 1872 (88); and the Georgia Historical Society, Savannah, October 9th, 1872 (88).

Donations to the library were received from the Academies at St. Petersburg, Vienna, Brussels and Boston; the Observatories of Dorpat and Montsouris; the Societies at Görlitz, St. Gall, Frankfort, Falmouth and Edinburgh; the Italian Geological Committee at Florence; the Geographical Antiquarian and Anthropological Societies, and M. Delesse, at Paris; the Meteorological, Geographical, Chemical, Geological and Zoological Societies, at London; the Revue Politique and Nature; the Peabody Museum, at Boston; Silliman's Journal; the American Chemist; the American Journal of Medical Sciences and Medical News; the American Journal of Pharmacy; Dr. Gross, of Philadelphia; Penn Monthly; and the Smithsonian Institution.

The death of Prof. John F. Frazer, a member of the Society, at the University, on Saturday, October 12th, in the 61st year of his age, was announced by Professor Kendall. On motion, Dr. LeConte was appointed to prepare an obituary notice of the deceased.

A paper for publication in the Transactions was presented, entitled, "On the Physical geography and geology of the island of Santo Domingo, with a map and four sheets of sections, by W. M. Gabb."

On motion, it was referred to a committee, consisting of Prof. Lesley, Dr. Leidy and Prof. P. E. Chase.

Communications were received from Prof. Cope, on a new Vertebrate Genus from the northern part of the Tertiary Basin of Green River, and descriptions of new Extinct Reptiles from the Upper Green River Eocene Basin, Wyoming.

Professor Chase explained his views of the values of his published comparative rainfall tables, and of the predictions permitted by his discussion of the same.

Pending nominations Nos. 697 to 705 were read. Nos. 697 to 702 were spoken to and balloted for.

Mr. Price read a letter from the Hon. W. S. Stokeley, Mayor of Philadelphia, in reference to the deposit of the Continental chair in the Hall of the State House.

The ballot boxes being scrutinized by the presiding officer,

the following named gentlemen were declared to be duly elected members of the Society:

Mr. Andrew Jackson Cassatt, of Philadelphia.
Mr. Clarence King, U. S. Geologist.
Mr. Horatio Hale, of Canada.
M. Paul Broca, M.D., of Paris.
Herr Franz Joseph Lauth, of Munich.
Dr. Isaac Norris, Jr., of Philadelphia.

And the meeting was adjourned.

ON A NEW VERTEBRATE GENUS FROM THE NORTHERN PART OF THE TERTIARY BASIN OF GREEN RIVER.

By Edward D. Cope, A.M.

(*Read before the American Philosophical Society, Oct. 18, 1872.*)

ANAPTOMORPHUS ÆMULUS. Cope.

Dentition of the *ramus* mandibuli, In. 2, C. 1, P.M. 2, M. 3, total, 16; identical in number to those of *Simia* and *Homo*. It differs in many respects from these; there is no interruption in the series near the canine, and the symphysis though massive, is not co-ossified. Further details are, the last molar is three-lobed and elongated behind. The composition of the crowns of the preceding molars consists of four opposed lobes, which are very stout, and connected transversely by a thin ridge behind, or in close contact in front. The premolar tooth which is best preserved, is a perfect second, which, while having two roots, possesses a crown which stands almost entirely on the anterior, presenting a curved sectorial crest forwards and upwards.

Measurements.	M.
Length dental line	0.0148
" of last molar	.0030
" " ante-penult	.0025
Width of "	.0020
Length of three molars preserved	.0070

DESCRIPTIONS OF NEW EXTINCT REPTILES FROM THE UPPER GREEN RIVER EOCENE BASIN, WYOMING.

By E. D. Cope.

CROCODILUS (ICHTHYOSUCHUS) SUBULATUS. Cope, sp. nov.

Some of the cervical vertebræ without hypapophyses. Their cups round. Dentition peculiar. One or two very long smooth compressed straight teeth in the front of the ramus mandibuli. These are followed abruptly by a closely set series of sub-equal teeth of not one-fourth the

size, varying little to the back of the jaw. The long teeth have sub-compressed crowns with opposed cutting edges, and are smooth except at their bases. These are distantly sulcate, the separating ridges being acute. The smaller teeth are perfect cones and resemble those of Gars without their sulci.

There are more long teeth in the premaxillary bone than below. Pitting of cranium distinct, elegant. Length of skull about one foot. Length of long teeth 1.25 inches; of small ones .5 inch.

CROCODILUS SULCIFERUS. Cope, sp. nov.

A medium sized species with cranium deeply and roughly pitted. The chief character is at present visible in the teeth. The larger of these are of sub-cylindric and short conic crown, which is superficially grooved from basis to near apex; sulci coarse, open.

ANOSTIRA RADULINA. Sp. nov.

Based on two marginal bones one from the front, the other from the rear, of the carapace of an animal of twice the bulk of the largest *Anostira* yet found. Apart from size, the sculpture is peculiar. It consists in the anterior of closely packed vermicular ridges which run out flat on the posterior and upper edge. In the posterior, it consists of only closely placed minute tubercles over the whole surface.

	M.
Length front one on free edge	0.025
Width " " "	.028
Length posterior on free edge	.025
Width " " "	.025

RECENT MONTHLY RAINFALL IN THE UNITED STATES.*

BY PLINY EARLE CHASE.

(*Read before the American Philosophical Society, November 1st, 1872.*)

General Myer has kindly favored me with a transcript of the monthly reports of rainfall at the several Signal Service Stations, from October, 1871, to September, 1872, both inclusive. The reports were arranged, at my suggestion, in six groups, in order to exhibit the local influence of proximity to the great lakes, the gulf, or either ocean, and of situation on opposite sides of the Mississippi Valley. In the interpolations (which are all enclosed in brackets), for months in which the Bureau received no returns, I have usually given more weight to the general rainfall of the section than to the local precipitation. The deficient Philadelphia report, for October, 1871, was supplied from the records at Pennsylvania Hospital.

*Published by permission of Brigadier General Albert J. Myer, Chief Signal Officer, U. S. A.

Having thus completed the tabular data, I computed the normal percentages from the fourth successive means, in accordance with the general plan of my previous meteorological papers. The resemblance between the lake curve and the two interior curves is more striking, and the lake influence is less marked than I anticipated; the opposition between the Pacific and interior curves exhibits the effects of differences of temperature between polar and equatorial currents, in the air and ocean, at opposite seasons; the differences between the Atlantic, the Pacific, the Gulf, and the land curves, are quite as striking as any of the differences between the curves of lunar-monthly rainfall at different stations; and a *larger proportion of the solar than of the lunar influence is disguised*, by aggregating the accompanying six sets of solar normals, and the seven sets of lunar normals in the foregoing communication.

Monthly Rainfall of* 1871—2 *at United States Signal Service Stations.

GULF STATIONS.

Stations.	1871, Oct.	Nov.	Dec.	1872, Jan.	Feb.	Mar.	Apr.	May	June	July	Aug	Sep.
Indianola......	(2.27)	(1.61)	(.73)	(1.25)	(1.72)	(2.10)	(1.49)	1.08	0.86	1.49	2.84	0.81
Galveston......	17.81	5.67	2.40	4.61	2.27	2.77	5.96	2.21	3.39	0.34	2.63	2.33
New Orleans..	9.09	7.14	1.46	5.10	4.77	9.18	5.01	3.14	5.34	6.43	3.75	2.10
Shreveport.....	(6.18)	3.04	1.30	5.25	5.89	4.11	7.18	9.10	2.70	1.62	0.40	2.91
Vicksburg......	4.13	7.03	2.05	3.24	5.34	7.82	7.79	13.23	3.82	2.11	0.49	0.72
Mobile.........	5.33	6.68	1.36	3.69	8.00	12.76	4.35	3.78	6.33	13.57	1.69	2.11
Lake City......	5.03	3.99	2.05	2.41	3.02	9.59	1.90	0.20	5.29	3.86	5.25	4.53
Punta Rassa....	1.80	0.98	2.68	2.64	2.71	0.69	1.54	2.88	7.16	8.68	3.97	5.14
Key West......	3.25	1.90	3.32	1.60	7.19	1.04	0.08	1.01	2.14	6.92	4.89	3.15
	54.89	38.04	17.35	29.79	40.91	50.06	35.30	36.63	37.03	45.02	25.91	23.80

LAKE STATIONS.

Milwaukee.....	3.37	2.54	1.55	0.90	0.34	0.53	1.84	2.92	3.67	1.98	1.89	8.72
Chicago........	(2.29)	3.62	3.44	0.68	0.84	3.78	3.03	2.76	8.45	3.09	2.59	6.43
Cairo...........	3.81	2.93	4.25	1.44	2.26	2.02	4.52	5.00	1.79	3.45	0.19	2.56
Indianapolis....	1.54	3.52	2.39	1.17	1.41	1.31	3.26	3.22	3.28	10.95	2.69	2.81
Cleveland......	0.60	2.42	0.84	2.00	0.80	1.30	2.22	3.99	2.68	6.19	4.53	3.47
Toledo..........	0.78	1.48	1.91	1.20	1.10	1.68	1.87	3.97	3.96	5.76	1.16	3.38
Cincinnati......	1.80	4.18	3.27	0.60	1.67	1.47	5.14	4.70	3.81	7.01	2.21	1.62
Marquette......	2.97	0.65	0.33	0.39	0.31	0.37	0.88	6.60	3.32	4.79	2.74	8.30
Escanaba	2.94	1.94	1.41	0.90	1.19	1.24	1.50	7.21	2.45	7.11	2.87	3.97
Grand Haven..	1.75	2.33	1.38	1.54	0.64	1.64	2.31	2.94	2.27	1.46	6.31	9.37
Detroit.........	0.69	2.76	1.88	1.05	0.69	1.22	2.15	5.64	2.85	2.63	2.60	3.84
Buffalo.........	1.64	3.60	2.55	1.94	2.21	1.30	1.43	2.23	3.52	1.66	1.94	4.34
Rochester......	2.59	3.10	1.82	2.37	1.28	2.50	2.15	2.18	5.35	2.56	1.89	1.72
Oswego.........	1.44	2.96	1.30	1.48	1.17	2.43	1.44	2.72	4.48	1.84	0.71	2.44
Burlington.....	2.75	0.73	0.78	0.42	0.13	0.13	0.73	3.59	8.66	7.27	9.70	3.38
	30.96	38.76	29.10	18.08	16.04	22.92	34.47	59.67	50.54	67.75	44.02	66.35

PACIFIC STATIONS.

Portland, O.....	(2.59)	2.77	7.62	6.56	12.13	5.28	2.96	0.92	1.52	0.20	.13	1.26
San Francisco..	07	2.81	14.36	4.03	6.90	1 59	0.81	0.18	0.04	0.01	.00	0.04
San Diego......	(.64)	1.19	1.39	0.99	1.63	0.46	0.26	0.12	.00	.00	.18	.00
	3.30	6.77	23.37	11.58	20.66	7.33	4.03	1.22	1.56	.21	.31	1.30

WESTERN INTERIOR.

Stations.	1871, Oct.	Nov.	Dec	1872, Jan	Feb.	Mar.	Apr.	May	June	July	Aug	Sep.
Fort Benton....	(1 17)	(1.15)	1 30	0.27	0.34	0 82	0.67	0 64	1.14	4.62	0.61	1.82
Virginia City..	(.98)	(.96)	1.43	1.46	0.79	0 20	0.35	1.78	0.74	2 73	0 60	0.28
Corinne........	0.35	3.22	4.04	0.70	2.42	.55	1.43	2.66	0.47	0.11	1.04	0.14
Cheyenne.......	0.24	0.66	0.16	0.02	0 27	0.38	1.61	1.99	1.84	3.90	2.05	1.03
Denver City....	(1.67)	(1.63)	(1.04	0.55	0.22	1.71	2.09	3.74	2.07	2.69	1.65	1.57
Santa Fe.......	(.97	(.95)	(.61	0.34	0.20	0.13	3.14	0.45	2.44	2 62	2.98	0.27
Omaha..........	2.06	4.22	0.91	0.09	0.43	1.61	3.84	3.91	6.35	6.36	1.78	3.24
Fort Sully.....	(1.76,	(1.72	(1.10	(.35	(.49	(1.06)	(1.78)	2.98	2.34	6.48	1.53	0.21
Leavenworth...	4.25	3.94	0.73	0.13	0.87	1.95	2.98	7.91	4.75	9.92	6.56	4.22
Duluth.........	4.19	1.47	2.05	0.86	0.46	0.86	1.80	4.62	4.46	5.83	2.84	5.01
Breckenridge...	2.35)	(2.30	(1.48	(.46	(.66)	(1.41)	(2.37,	4.05	5.10	6.01	1.78	1.18
St. Paul........	1.90	1.41	1.20	0.28	0.26	1.64	1.69	5.71	3.81	4.23	3.52	5.62
Davenport......	3.19	3.33	1.61	0.13	0.10	1.82	5.06	4.46	3.78	3.80	8.91	5.30
Keokuk.........	5.22	2.89	1.46	0.07	0.39	2.88	3.66	3.70	5.81	6.77	1.97	2.26
St. Louis.......	2.07	1.83	1.17	0.64	1.15	2.43	3.17	5.97	4.28	4.41	0.93	3.45
	32.37	31.68	20.29	6.34	9.05	19.44	32.64	54.57	49.38	70.48	38.75	35.60

EASTERN INTERIOR.

Nashville.......	1.31	2.13	1.65	2.32	2.11	3.09	5 91	3.09	5.17	4.90	1.65	4.50
Knoxville	4.28	2.61	3.27	2.99	2.24	3.04	3.61	2.86	6.68	2.29	6.27	3.89
Louisville......	1.85	2.51	3.29	2.18	2.26	1 41	8.40	4.49	6.19	3.67	2.45	4 41
Memphis	4.04	2.23	1.62	2.17	4.24	5.19	6.99	4.16	4.44	4.23	0.54	3.62
Pittsburgh.....	2 66	3.30	2.00	1.85	0.97	1.33	0.88	2.61	2.35	7.70	2.81	2 54
Philadelphia...	4.86	4.09	1.57	0.95	1.12	3.67	2.60	3.15	4.29	9.20	7.81	3.66
	19.00	16.87	13.40	12.46	12.94	17.73	28.39	20.36	29.12	31.99	21.53	22.62

ATLANTIC STATIONS.

Portland, Me...	6.55	6.37	3.00	0.77	0 35	1.44	1.60	3.23	5 95	2.87	6 97	3.12
Boston..........	5.88	6.42	3 38	2.11	2.31	4 05	1.31	3.29	4.84	4.00	10.68	6.04
New London....	8 35	5.50	2.78	2 46	0.96	2.93	2.30	3.16	2.78	5.35	6 06	6.96
New York......	7.07	3.76	1.19	2.34	1 44	3.93	2 49	2.25	2 93	9.36	6.08	3.44
Baltimore......	3 11	3 24	1.90	0.88	1.46	3.06	3 06	1.44	4 16	1 58	4 59	5.06
Cape May......	4.91	6.42	2.90	2.99	2.99	6.61	0.92	1 50	2.15	3.27	3.09	4.51
Washington....	1.50	4.85	1.36	0.23	0.93	3.22	1.74	1.43	2.78	0.82	5 72	3 92
Lynchburg.....	1.60	3.76	1.12	2 08	1.99	4.24	3.20	3.15	2.53	1.56	2 27	1.26
Norfolk.........	4.14	5.76	2.18	2.91	7.33	4.51	3.53	5.68	5.06	3.63	3.20	2.40
Wilmington....	3 02	4 46	3.90	3 62	5.20	6 42	0.97	4.89	2.87	5.54	11 15	8 22
Charleston.....	4.76	4.09	3.67	3.78	5.13	9.78	2.46	6.30	1.87	2 30	7.81	7 88
Savannah	3.55	2.22	1.59	2.09	4.65	10.18	2.75	5.22	9.52	4.36	12.31	3.52
Augusta........	1.62	7.78	5.98	4.20	5.87	10.88	2.95	5.36	4.77	6.87	4.10	1.33
Jacksonville....	3.62	3.63	2.65	3.44	2.70	7.32	2.39	1.25	6.97	2.92	6.41	10.65
	59.68	68.26	37.60	33.90	43.31	78.57	31.67	48.15	59.18	54.53	90.44	68.35

Normal Percentages of Rainfall.

	Atlantic Stations.	Gulf Stations.	Pacific Stations.	Lake Stations.	Western Interior.	Eastern Interior.	Mean Solar.	Mean Lunar.*
January..........................	75	86	239	55	39	65	93	99
February.........................	87	107	209	51	39	73	94	97
March	95	116	143	66	64	93	96	98
April..............................	89	110	73	95	103	111	97	101
May...............................	87	104	34	124	140	122	102	100
June...............................	99	105	18	140	162	132	109	104
July	116	100	10	143	162	133	111	103
August............................	128	90	12	138	138	120	104	106
September.......................	126	95	27	126	112	106	98	104
October...........................	115	107	70	107	98	93	98	96
November	109	98	147	87	83	81	99	95
December	82	61	218	70	59	70	97	98

* The twelve normal ordinates of the Mean Lunar curve are obtained from "Aggregate B." in the "Normals of Lunar-Monthly Rainfall." The aggregates for two and a half days are added together, to obtain the normal aggregate for one-twelfth of a month, and the normal percentages computed from the results. E. g.; the 1st day, added to three-fourths of the sum of the 30th and 2d days, gives the normal aggregate for the 1st twelfth; the 3d and 4th days, added to one-fourth of the sum of the 2d and 5th days, gives the normal aggregate for the 2d twelfth

LUNAR-CYCLICAL RAINFALL IN THE NORTHERN TEMPERATE ZONE.

By Pliny Earle Chase.

(*Read before the American Philosophical Society, Nov. 1, 1872.*)

My discussions of lunar-monthly rainfall, (*ante*, x., 439, 583; xi., 203; xii., 179, 523,) embracing observations in Europe, Asia and America, near eastern and western shores of oceans, in regions of monsoons and return trade-winds, near equatorial and polar currents, seem to be sufficiently varied in their character to justify a first approximation to the normal curve for the Northern Temperate Zone. The stations are so well distributed that the influence of local "establishments" must be, to a great extent, eliminated, and it seems reasonable to presume that the residuals represent, with some degree of accuracy, the precipitation which is occasioned by the lunar modifications of the average atmospheric currents. I have given equal weight to the normals for each station, but as the Toronto observations cover only nine years, and those at Chiswick are of the same general character as those at Surrey, I give two complete aggregates: A., embracing stations 2 to 6 inclusive, and B., 2 to 8 inclusive; and one partial aggregate, C., for all the stations.

NORMALS OF LUNAR-MONTHLY RAINFALL.

Lunar Day.	Mussoorie, 13 years.	Philadelphia, 40 years.	Surrey, 40 years.	Providence, 30 years.	San Francisco, 23 years.	Lisbon, 16 years.	Aggregate A.	Chiswick, 40 years.	Toronto, 9 years.	Aggregate B.	Aggregate C.
1	86	93	100	104	97	104	498	104	93	695	781
2		93	98	100	97	103	491	105	104	700	
3		96	97	98	94	98	483	105	103	691	
4		100	100	98	92	91	481	105	94	680	
5		101	102	100	96	86	485	103	92	680	
6		99	102	103	104	81	489	100	100	689	
7		97	100	107	107	81	492	96	113	701	
8	115	97	101	107	108	85	498	97	117	712	827
9		97	105	101	107	91	501	102	110	713	
10		98	107	93	103	94	495	106	98	699	
11		98	104	87	97	110	496	105	91	692	
12		97	101	85	99	123	505	103	95	703	
13		95	98	87	110	128	518	101	105	724	
14		92	97	90	125	123	527	98	110	735	
15		89	98	90	138	116	531	98	104	733	
16	86	91	98	89	134	114	526	98	91	715	801
17		99	97	93	115	118	522	96	85	703	
18		109	96	99	105	127	536	93	90	719	
19		116	97	104	104	131	552	95	102	749	
20		117	99	108	96	123	543	102	110	755	
21		112	103	111	85	104	515	109	110	734	
22		107	104	110	83	82	486	108	104	698	
23	113	105	101	106	86	69	467	101	103	671	784
24		105	98	102	88	70	463	95	106	664	
25		102	99	99	89	77	466	93	108	667	
26		98	101	99	86	84	468	94	106	668	
27		100	100	103	81	89	473	94	101	668	
28		103	90	109	85	95	491	95	91	677	
29		100	100	111	93	99	503	98	81	682	
30		95	101	108	96	102	502	101	82	685	

Each of the complete aggregates indicates an excess of rainfall during

the half-month of lunar opposition ; a pretty regular increase of rain from the first octant, when the moon is on the meridian at the time of greatest solar heat, until nearly the fifth octant, when her direct meridional influence is exerted at the time of morning low barometer ; average rain when that influence is felt at sunset, or at the morning barometric maximum ; a principal maximum, near the morning barometric minimum, and a principal minimum near sunrise, when the nocturnal precipitation is over ; other minima soon after sunset, after the maximum heat of the day, and after midnight. These features all seem so natural and so simply explicable, that I am unable to regard them as other than typical.

I regret that Mr. Hennessey's observations at Mussoorie were communicated only for the days of quarterly change. They appear to indicate a curve still more strikingly similar to that of the solar-hourly rainfall, and the indication is corroborated by their influence on the general aggregates, as shown in Aggregate C.

It would be possible, even with the data now at my command, to form interesting approximations to the normal lunar curves for each calendar month, but I prefer to wait for observations from a much larger number of stations, before undertaking any more minute calculations than I have embodied in the accompanying table. Even these normals may be employed in connection with barometric and thermometric normals in the study of weather changes ; provided such allowances are made as are obviously required, for the blending of currents over or near the great Lakes, the Gulf, and the ocean. Such limited use of them as I have already made, has strengthened my conviction that the day is not far distant when the normal lunar influence will be ranked among the important elements for calculating the disturbances, and the tendencies towards equilibrium, which determine all meteorological fluctuations, and render satisfactory forecasts practicable.

Stated Meeting, November 1, 1872.

Present, 16 members.

Vice-President, Mr. FRALEY, in the Chair.

The Rev. Mr. Nichols, a newly elected member, was presented to the presiding officer and took his seat.

A circular letter in reference to a new table of logarithms was received from Mr. Ed. Sang, dated No. 2 George street, Edinborough, Oct. 15th, 1872.

A letter was received from Dr. William Elder, addressed to the Curators, dated No. 1824 Mount Vernon Street, Philadelphia, Oct. 31st, 1872. On motion the Curators were

desired to acknowledge the donation of the Bushrod Washington Chair, described in the letter, and to return the thanks of the Sooiety for the same.

Letters of acknowledgment were received from the Rhode Island Historical Society, (Proc. 88) and Yale College Corporation (Proc. 88).

Donations for the Library were received from the Revue Politique, and London Nature, the Geological Survey of New Hampshire, Silliman's Journal, and the Franklin Institute.

The Committee to which was referred Mr. Lyman's map and description of the Staley's Creek Iron Ore District, reported in favor of its publication in the Transactions. The report was accepted and the publication ordered.

The Committee to which was referred Mr. Gabb's Memoir on the Geology, &c., of Santo Domingo, reported in favor of its publication in the Transactions. On motion the report was accepted and the publication ordered.

The death of Mr. Constant Guillou, at Philadelphia, the 20th ult., was announced by the Secretary.

Mr. James desired to place on the minutes that he had duly returned the MSS. letter of Dr. Franklin and the map accompanying Pursh's MSS., Botanical Journal, which he had been permitted to borrow from the library.

Dr. Emerson exhibited one of the bricks of a chimney scattered by lightning in the storm of the 25th ultimo; a chimney belonging to a house in which he was sleeping at the time.

Mr. Lesley desired to place on record authentic data respecting fourteen oil wells sunk by the Brady's Bend Iron Company, at and near their works, on the Allegheny River; and explained the importance of facts, so obtained, when comparable, in view of the general inaccessibility of the Sub-carboniferous formations underlying the Oil Regions. A discussion of oil theories and of the history of the oil discoveries followed, in which Mr. Lyman, Mr. Gabb, Dr. Le Conte, and other members took part.

Mr. Chase offered for publication in the Proceedings a first approximation to a curve of Normal Temperature in the Northern regions of the Continent.

Mr. A. H. Smith described his observations of the Subalpine botany of the North Shore of Lake Superior, in the Summer of 1871, and of its absence in the Lake Nibbegong region, further north, which he had explored in the Summer of 1872; this change of flora he was led to ascribe to the fact that the waters of Lake Superior were much colder than those of Lake Nibbegong. His collection of mosses he had placed in the hands of Mr. James for examination. He described the ascent of the Nibbegong River and the thousand islands in the lake itself, which has scarcely been visited by any observers who could report scientific facts.

Mr. Gabb instanced an analogous change of flora from the coast to the interior of the northern part of Lower California.

Dr. Le Conte said that he would assign a hygro-metric cause for this difference, and added that a similar difference was known to exist between the faunæ of the coast and the interior as far across as to the banks of the lower Rio Grande; and that the line of distinction was sharp and sudden, being drawn along the summit of the coast range of mountains, a barrier not more than 3000 feet high at the place to which he referred. It was evident that the wet winds of the west flank of this barrier and the dry air of its eastern, which made the change in flora and fauna.

Professor Haldeman introduced the topic of the Rhyme-law of the Sonnet in European literature. He had made extensive collections of Sonnets and studied their construction for the purpose of discovering a normal rhyme arrangement. So far from that, he had already tabulated 600 (six hundred) arrangements of the sonnet with a prospect of adding to his tables more.

Pending nominations, Nos. 703 to 707 were read.

And the meeting was adjourned.

A Record of Fourteen Oil Wells at Brady's Bend, Armstrong County, Pennsylvania.

By. J. P. Lesley.

(*Read before the American Philosophical Society, Phila., Nov, 1st, 1872.*)

Having recently requested Mr. Persifor Frazer, Assistant Professor of Chemistry in the University of Pennsylvania, to examine for new estimates of quantity the coal areas which have escaped erosion, in the country on the two sides of and closely adjoining the Allegheny River, at the remarkable ox-bow bend in its course, 70 miles above Pittsburgh and 60 miles below Oil City; he brought back with him a MSS. report of of the wells bored by the company on the river banks and along the beds of the ravines descending to it from the west. We owe this report to the kindness of Stephen Halbrook, Esq., Superintendent of the Brady's Bend Iron Works.

It is needless to recapitulate the history of the oil discoveries, and the gradual extension of the oil producing districts from Titusville and the line of Oil Creek eastward to the Tidioute district, southeastward to the Clarion, westward to French Creek, and southward via Oil City, Franklin, Parker's Landing, and Brady's Bend, to the neighborhood of Butler, where the last discovery excitement is now raging. It is only necessary to refer to my report on the geological grounds for believing the middle Allegheny River districts to be productive oil country, published in the Proceedings of this Society, in 1865.* In that paper I have sufficiently described the *locale* of the wells now to be described. These records may also be compared with similar records communicated to the Society and published in its Proceedings of April, 1865.

The "Engineers' Datum" of the following table is an assumed level, *one hundred feet lower* than a mark made on the Brady's Bend Iron Company's warehouse, on the river bank, showing the extreme height reached by the great and disastrous freshet of March 17, 1865.

No.	Height of well mouth above Eng. datum.	Depth of well.	Depth below river, highest water mark.	First yield in barrels per day.	Present yield per day.
1..	96 feet.	?	?	?	1 bbl.
2..	232	1,400	1,268		*no sand rock.*
3..	97.62	1,111	1,113	5¼ bbls.	1 bbl.
4..	97.69	1,262	1,264		*abandoned.*
5..	100.31	1,105	1,105	7 bbls.	2 bbls.
6..	300.48	1,290	1,090	5½ bbls.	4 bbls.
7..	437-41	1,414	1,077	9 bbls.	8 bbls.
8..	379.18	1,345	1,066	840 bbls.	150 to 200 bbls.
9..	101.38	1,065	1,066	4½ bbls.	3 bbls.
10..	330.27	1,300	1,070	1 bbl.	*abandoned.*
11..	111.13	1,200	1,189		*powerful gas blow.*
12..	216.50	1,212	1,095½	12 bbls.	13 bbls.
13..	426.38	1,402	1,076	3 bbls.	2 bbls.
14..	359.89	?			*to be sunk to 4th sand.*

* See Proc. A. P. S., vol. 10. p. 61.

From the above table, it appears that all the oil-producing wells mentioned in it get their supply from one stratum lying in an undisturbed and horizontal position, varying in their actual depths below a fixed datum level from 1,113 to 1,066 feet, a difference of only 40 feet. This difference is due to three causes, viz. :—1. The different depths in the oil-bearing stratum penetrated by the bottom boring of the wells; 2. The slight inequalities in the upper surface of the stratum; 3. And chiefly, to a general slight dip of the rocks, both from the northwest and from the southeast, in towards the centre line or axis of the trough or basin which here crosses the Allegheny River in its northeast-southwest course; and also to a still slighter and almost insensible decline of the axis of the basin itself southwestward.

The table also confirms what was proven years ago, long before the fact was acknowledged by oil men, namely, that it makes no difference whether a well is started in the valley bottom or on the hill tops, provided it goes down to the uniform and nearly horizontal oil-bearing sandrock. For some of these wells have their mouths at elevations more than 300 feet greater than others. Some on the river bank, and others high up at the heads of side ravines. The great No. 8 well was commenced at an elevation 379—96=) 283 feet higher than those on the river bank which yield only from one to three barrels a day.

The following table shows the thickness of the third sandrock where it was passed entirely through :

No. 2.—No sandrock found and no oil.

No. 4.—Sandrock, 26 feet; hard fine white sand.

No. 5.—Sandrock, 27 feet; fine pebbles.

No. 6.—Sandrock, 16 feet; with slate partings.

No. 7.—Sandrock, 27 feet; pebbles pretty coarse.

No. 8.—Sandrock, very coarse and open.

No. 9.—Sandrock, pebble very fine and close, very little gas.

No. 10.—Sandrock, 10 feet; pebbles pretty fine, except in one thin streak.

No. 11.—To sandrock, no oil, but great gas blow, doubtless from a fissure.

No. 12.—Sandrock, 17 feet, all pebbles; steady flow of oil.

No. 13.—Sandrock, 13 feet; coarse open pebbles; and a fair amount of gas.

No. 14.—Sandrock, 13 feet; large coarse pebbles; fair amount of gas.

Other noteworthy facts are as follows :

No. 1 well, on the river bank, one half mile above the rolling mill, begun March, 1865, finished 1866.

No. 2 well, at the mouth of Cove Run, May, 1866—June, 1870.

No. 3 well, on the river above the mill, commenced August, 1868—pumping in September, 1872, 1 barrel a day.

No. 4 well, on the river above the mill, May, 1869—March, 1870. Cost $10,405. Record of strata given below.

A Record of Fourteen Oil Wells at Brady's Bend, Armst County, Pennsylvania.

By. J. P. Lesley.

Read before the American Philosophical Society, Phila., Nov, 1

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4	97.69	1,262	1,264
5	100.31	1,105	1,105
6	300.48	1,290	1,09[illegible]
7	437-41	1,414	1,07
8	379.18	1,345	1,0
9	101.38	1,065	1,[illegible]
10	330.27	1,300	1
11	111.13	1,200	1
12	216.50	1,212	
13	426.38	1,402	
14	359.89	?	

* See Proc. A. P. S., vol. 10, p

-71;
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she produces from 70
at 20 to 25, when it is
fifty weeks she has pro-
ept when flowing.
June 24, 1871—October 24,

July 10, 1871—May 22, 1872;
third sand at 1,300 feet, put in
very little effect. Sand pumped
she filled up with less than a bar-
ded it was useless to tube her.

the mill; August 24, 1871—June
Struck very heavy vein of gas at

would supply fuel to run the
, being therefore equal to 100 tons

lift the tools 20 or 30 feet in the
rope 800 pounds. The flow of gas

; December 9, 1871—April 12, 1872;
heavy vein of gas February 2, at

No. 5 well, on the river above the mill, June, 1869—April, 1870. At 931 feet struck so powerful a gas vein, that the bore-hole was deluged with water and abandoned for four months. In June, 1871, a three quart nitro-glycerine torpedo was exploded without increasing the production of oil. The pebble rock was almost as fine as sea-sand.

No. 6 well, on Queenstown Run; August, 1870—April 5, 1871; drilled with the water cased out; all the previous wells were drilled in water; casing commenced at 357 feet; not much gas.

No. 7 well, on Queenstown Run; August 7, 1870—March 1, 1871; water cased out at 512 feet; some gas at 1,050; commenced pumping about 9 barrels a day, and has produced up to September 7, 1872, 4,133 barrels.

No. 8 well, on Queenstown Run; June 26, 1871—September 22, 1871; water cased out; first show of oil September 22, and began to fill up very slowly. At 12.35 A. M., September 23, struck a vein of gas and oil which spouted over the top of the derrick, and was fired by the night lamp hung in the derrick, burning the rigging down. The spouts occured every two minutes. At 9 A. m. the fire was extinguished and the oil began to fill the tank at the rate of 35 barrels an hour, but gradually calmed down to about 60 barrels a day during the first month, and October 22 ceased to flow. Tubeing and sucker rods were then put in, and she began to flow again at the rate of 150 barrels a day.

This well has been cleaned out many times to keep her in good running order. Immediately after any one such cleaning she produces from 70 to 90 barrels a day, and gradually falls off to about 20 to 25, when it is understood that she again needs cleaning. In fifty weeks she has produced 9,505 barrels. There is not much gas except when flowing.

No. 9 well, on the river opposite Catfish; June 24, 1871—October 24, 1871; water cased out; cost $5,750.

No. 10 well, on Lower Campbell Tract; July 10, 1871—May 22, 1872; water cased out. After passing through third sand at 1,300 feet, put in a 4 quart torpedo, which seemed to have very little effect. Sand pumped for two days afterwards and found that she filled up with less than a barrel of oil per day, and therefore concluded it was useless to tube her. Not much gas at any time.

No. 11 well, on river half mile below the mill; August 24, 1871—June 24, 1872; water cased out at 437 feet, Struck very heavy vein of gas at 858 feet.

The gas from this well, by calculation, would supply fuel to run the rolling mill and machine shop boilers, being therefore equal to 100 tons of coal per week.

The pressure of gas would sometimes lift the tools 20 or 30 feet in the hole, tools weighing 1,700 pounds and rope 300 pounds. The flow of gas is enormous and continuous.

No. 12 well, on Queenstown Run; December 9, 1871—April 12, 1872; water cased out at 394 feet. Struck heavy vein of gas February 2, at

725 feet, which caused a flow of water until March 1, when casing was put in and the water stopped off.

Struck oil at the top of third sand April 4, at 1,183 feet, the rock being nearly all good pebble rock; after passing through it (1,200 feet) drilled 12 feet into slate for a pocket; tubed well April 12; commenced pumping 12 barrels a day, and the well is now doing 13 barrels. Much gas all the time. Cost $6,557.

No. 13 well, on Queenstown Run; January 2, 1872—May 8, 1872; water cased out at 290 feet. Best show of oil at 1,390. Cost $6,671.

No. 14 well, on Queenstown Run; June 11, 1872—September 2, 1872; water cased out at 227 feet. Little oil in third sand; will push it deeper.

It only remains to give vertical sections of the Measures passed through, premising, that the Great Conglomerate No. XII, the base rock of the Coal Measures forms the low cliffs at water level in the river valley; all the hills being built up of the nearly horizontal Lower Coal Measures or Allegheny River System, and the underground of Sub-Carboniferous and Devonian.

The following records of wells No. 4 and No. 5 of the foregoing description were made from labels on sample bottles, marked daily by the well drillers, and are not supposed to be perfectly reliable, but are nevertheless for the most part accurate notations of the character of the Sub-carboniferous and Upper Devonian Measures penetrated in reaching the oil-bearing strata.

RECORD OF OIL WELL NO. 4.

Struck the "mountain sandrock" at a depth of 50 feet.

Got through it at	240 feet.
Grey sand at	898 "
Grey sand at	933 "
Grey sand at	940 "
Dark gray sand	944 "
Black slate	947 "
Dark rock	952 "
Dark rock	955 "
Gray sand	965 "
Slate rock	976 "
Black rock	992 "
Black sand	998 "
Grey sand	1,008 "
Grey sand	1,003 "
Blue sand, hard	1,005 "
Black sand, hard	1,008 "
Blue sand, pretty hard	1,012 "
Slate rock	1,015 "
Hard sand	1,038 "
Sand	1,085 "

Sandrock	1,100 feet.
Red sandstone	1,126 "
Black sand	1,140 "
Grey sand	1,141 "
Grey sand	1,143 "
Mud	1,144 "
Blue slate	1,145 "
Soft slate	1,146 "
Soft slate	1,147 "
Shelly	1,148 "
Slate	1,150 "
Slate rock	1,152 "
"	1,162 "
"	1,165 "
Shelly rock	1,172 "
Slate rock	1,176 "
"	1,181 "
"	1,183 "
"	1,191 "
Blue slate	1,194 "
"	1,197 "
Shelly rock	1,211 "
Traces of oil	1,220 "
Slate	1,235 "
Slate rock	1,248 "
Dark slate	1,252 "
Slate—well abandoned at	1,260 "

RECORD OF WELL NO. 5.

Struck the mountain sandrock at	45 feet.
Got through it at	215 "
Grey sand	350 "
Slate rock	400 "
"	440 "
Soft slate rock	460 "
Grey rock	490 "
Slate rock	510 "
Slate shells	530 "
Slate rock	560 "
"	580 "
"	620 "
Shell rock	640 "
Slate rock	660 "
"	670 "
"	690 "
"	710 "

Sandrock	715 feet.
“	720 “
“	730 “
Slate rock	745 “
Red rock	750 “
Pebble rock	775 “
Sandrock	779 “
“	780 “
“	790 “
Slate rock	795 “
Sandrock	805 “
Red rock—	
Grey sand	808 “
Sandrock	812 “
“	815 “
“	820 “
“	822 “
“	824 “
“	826 “
Red rock—	
White sand	825 “
Rock	830 “
“	840 “
Grey sand	844 “
“	847 “
“	848 “
Sandrock	850 “
Blue rock	855 “
Sandrock	860 “
Black sand	865 “
Sandrock	896 “
“	930 “
Red rock—	
Sandrock	939 “
“	940 “
“	941 “
“	943 “
Shelly rock	948 “
“	951 “
“	954 “
Slate Rock	965 “
Red rock	972 “
Hard sand	986 “
Soft sand	998 “
Dark rock	1,018 “
Red sandrock	1,026 “

Slate	1,050 feet.
Shelly rock	1,055 "
THIRD SAND rock	1,073 "
Sandrock	1,076 "
"	1,078 "
Slate and shelly	1,084 "
Pebble rock	1,085 "
"	1,090 "
Sandrock	1,092 "
" Tubed well	1,100 "

and began pumping about 7 barrels in 24 hours.

It is a pity that the above records are so defective. The intervals between the numbers given are in many cases large and not noted, and must not be taken as the *thicknesses* of the rocks named.

There is, however, a positive value in all such records, however defective, as may be noted by the recurrence of the *red rocks* in the above lists. These may define the position of the great red formation of the Palæozoic series No. IX of the Pennsylvania State Survey, the representative of the Old Red Sandstone of English geologists, and the Catskill Formation of the New York geologists.

In Well No. 4 it is noted once only as being struck at 1,126 feet.

In Well No. 5 it appears at 750, 805, 826, 930, 972 and 1,026 feet.

The thickness of the Conglomerate No. XII is accurately determined in Well 4 at 190 feet, and in Well 5 at 170 feet.

The thickness of the Conglomerate No. XII in the salt well 45 miles further down the river, as determined (not with entire accuracy) from the Record, published on p. 65, vol. X., of the Proceedings A. P. S., April 1865, is 494½ 334½ -- 160 feet; or, if the top of XII be placed at the "White Sand" 440½ and all the "Gray Sandrocks" be included down to 666″11, = 220 feet.

At Sligo Furnace on the Clarion (p. 63, vol. X.), the Conglomerate No. XII, seems to be only 117 feet thick, soft red slate of XI under it only 3 feet thick, and the red and blue slates of IX lie 786—183 = 603 feet below its base, or 720 feet below its top.

The resemblance of this to the record of Well No. 5, given above, is very observable. Thus, in Well No. 5, the red rocks of IX are first struck at 750—45 -- 715 feet beneath the top of the Conglomerate.

In the Sligo Well (15 or 20 miles to the northeast of it), the top of the red rocks is 786—66 = 720 feet beneath the top of the Conglomerate.

In the Well No. 5, the redrocks are noticed at intervals from 750 to 1026 = 276 feet.

In the Sligo Well, the red rocks occupy an interval of only 118 feet.

It must be taken into consideration, however, that the lowest red rocks of the well No. 5 may represent not No. IX, but the Red Beds of VIII, described in my report to Professor H. D. Rodgers, in 1841, and published in his Final Report of the Geology of Pennsylvania, under the

head of the Geology of the Wellsborough Valley or Tioga River District in Tioga County. To trace the thinning away of these calciferous and ferriferous red beds of VIII (Lower Divonian) on their way towards Ohio, underground, is one of the desiderata of American geology.

Other well-boring records are published on pages 227 ff, vol. X, Proc. A. P. S., but most of them are confined to the Coal Measures. Those on p. 238 ff, however, penetrate the Devonians to considerable depths and show the red rocks in positions analogous to those described above.

In one well, at the head-waters of the Clarion, the mouth of the well being 370 feet below a coal bed, and also below the bottom of XII, the red rocks of IX (?) occur from 216 to 415 = an interval of 200 feet, which is about the normal thickness of IX in this zone of its decresence westward. The Manchester (Tioga river) red beds (?) were struck at intervals from 925 to 956 = 41 feet, *i. e.*, with an interval of 510 between their top and the bottom of IX.

In the Glade Well near Pithole (page 241, vol. X), in the Oil Creek country, the red slates were first struck at 196 and got through at 318, the interval being 122 feet. Some red shale was then struck near the well bottom (abandoned, no oil) at 612, *i. e.*, 294 feet below the bottom of the upper red shales.

These also probably represent IX and the Manchester red beds, with a diminished interval due to westing.

These red rocks correspond to the Marshall group of Michigan, of Winchell (Proc. A. P. S., vol. XI., p. 74), the Gritstone redrocks above and the Chocolate shales below (the latter just over the Hamilton) in Ohio (Idem, p. 75), and to the Brown shales of the Keokuk group of Indiana. They are very noticeable to the traveller on the railways crossing Northern Ohio.

NOTE.—I have received the following letter of explanation respecting the wells at Brady's Bend:

ST. LOUIS, MO., *November* 13, 1872.

Dear Sir:—The detailed surveys were begun and mostly made under my direction, and the wells Nos. 6, 7, 8 and 9 were located by me. This would be of no interest to you or the public were it not that the location of these wells was the result of a long, carefully pursued, and at least apparently successful investigation into the laws of the distribution of the oil in the "sandrocks."

You had already shown that these rocks existed there and at what depth, and had also shown that the general stratography of the district rendered it reasonably certain that oil would be found there, and this had been confirmed by the results of boring in the case of two of the five wells sunk.

I tried to find the law of distribution in its application to narrower limits, so as to decrease to the utmost the risks, and increase to the utmost the chances in sinking wells.

Of the five sunk before I went there, two were productive; of the four sunk since I left, one is productive; of the four I located, namely, Nos.

6, 7, 8 and 9, all are productive. No. 9, which is the least productive of the four, was located under restriction to the Lower Campbell tract. No. 8, the most productive, was the last one I located without restriction. Nos. 6 and 7 were both down before any other well was started in the Whiskey Run or Queenstown Run field. The same principles which guided the locating these wells, led me to advise the Brady's Bend Iron Company against trying the Upper Campbell tract, and the results of boring there by other parties have confirmed their correctness, and there have been so many confirmations that my confidence in the principles amounts to conviction.

In opening the Whiskey Run or Queenstown Run field, I simply followed the general line of strike from the Armstrong Run field; but in locating individual wells I sought lines and areas of deposition of coarse pebbles in the "sandrocks" out of broken condition of the "sandrocks."

I had not so far completed the research into the laws which govern the direction and position of these lines and areas that I felt free to communicate them when I left the oil country, but hope to push the investigations further hereafter. Meanwhile it may be of some interest that the above results have followed an effort pursued by scientific methods to find and apply such laws.

Yours, very respectfully,

JAMES E. MILLS,

Vice President Big Muddy Iron Company.

Stated Meeting, November 15th, 1872.

Present, nine members.

Vice-President, Mr. Fraley, in the Chair.

A photograph of Mr. H. M. Phillips was received for insertion in the Album.

Letters accepting membership were received from Mr. Isaac Norris, Jr., dated Philadelphia, October 31st, 1872, and from Mr. A. J. Cassatt, dated 2030 Delancey Place, Philadelphia, November 6th, 1872.

Letters of acknowledgment were received from the Smithsonian Institution (Proc., No. 78), and the Nat. Verein at Bremen (87), September 7th, 1872.

Donations for the Library were reported from the St. Petersburg Observatory; Antiquarian Society at Copenhagen; R. Academy at Berlin; German Anthropological Society; Museum of Natural History at Paris; Paris Anthropological Society; Annales des Mines; Revue Politique; Nature; L. & H. S. Quebec; Boston S. N. H.; Yale College;

American Chemist; Penn Monthly; Am. J. of Pharmacy; Medical News; Academy of N. S. Philadelphia; and Dr. Jarvis, of Dorchester, Mass.

The death of Gen. George Gordon Meade, on the 6th instant, at Philadelphia, aged 56, was announced by Mr. Trego. On motion, Gen. A. A. Humphreys was appointed to prepare an obituary notice of the deceased.

Mr. Gabb described the results he arrived at in making up a summary from tables of undoubted Miocene fossils, collected by him during three years of exploration in Santo Domingo. These tables double the fauna hitherto described. Instead of the normal percentage of extinct to recent species according to Lyell's formulas, it appears that the San Domingo Miocene holds 217 extinct and 97 living forms; these living forms existing on both sides of the present barrier of Central America, on top of which barrier lie Miocene rocks. Mr. Gabb stated that he had just finished the study of the Miocene Fossil Mollusca, collected during his recent geological examinations in Santo Domingo. He found 217 extinct species, and 97 which he recognized as living; 15 of these latter are peculiar to the "Panama Province," having disappeared from the Caribbean waters since the Miocene period. One or two are found in the Eastern seas only, and others are now living on the opposite side of the Atlantic, or on the Atlantic coasts of North and South America; while still others are closely allied to species or belong to genera only living at present in the seas of Australia and Southern Asia.

The most interesting feature connected with these fossils, however, is that notwithstanding the proportion of living to extinct forms is about one-third, yet, from the "facies" of the collection, from the presence of antique types among the genera, and from the vertebrate remains, such as *Carcharodon*, *Megalodon* and other well-known Miocene species, there seems little doubt but that the formation was correctly referred to that age by previous writers, such as J. Carrick Moore, Etheridge, and Duncan.

Lyell established the rule many years ago, that the typi-

cal Miocene contains but 17 per cent. and the Pliocene from 35 to 50 per cent. of living species. But that rule, while it applies perfectly well to the local deposits on which it was based, is too empirical to be followed elsewhere, except in a very general manner and where the other data are in accord.

An essential objection to the numerical rule exists in the different values that students place on specific characters. No two writers agree on this subject. Besides, as regions become more thoroughly worked up, discoveries of additional fossils, or the finding of living species, previously known only as fossils, vary the proportions constantly. The general deductions, therefore, drawn by an experienced palæontologist from large collections, are safer guides than any table of percentages.

MUS. COMP. ZOOLOGY,
Cambridge, Mass., Dec. 3, 1872.

MY DEAR PROF. LESLEY:

The steamer did not sail on Saturday and I have availed myself of the delay to run up here. It was very fortunate, since I have had the opportunity of seeing Dr. G. A. Maack, and of learning from him some of his geological results on the late Selfridge Expedition on the Isthmus. Please have the following note added to my paper, with the permission of the Society:

The results of the explorations of Dr. Maack last year, on the Isthmus of Darien, put at rest the question of the late geological origin of the Isthmus. He found three late Tertiary strips extending entirely across, proving three channels at least in the Miocene, and some of the deposits indicate a much later era of elevation. One of these, 10 miles inland from Panama, evidently Post Pliocene, is at least 150 feet above the tide.

In a very cursory examination of his fossils I detected the following species, also found in Santo Domingo:

Melongena melongena.
Murex recurvirostris.
Malea ringens.
Terebra robusta.
Conus pyriformis.
Natica sulcata.
Cerithium plebium.
Turritella.
Cypræa exanthemata (v. cervinella).
Venus paphia.
Cardium Haytense.
Pecten papyraceus.

Dr. Maack in his report calls the older beds of Panama, Pliocene. They

seem to me nearer in age to the rocks which, in Santo Domingo, I called Miocene, but whatever be their real age, the one fact is well established : The Isthmus was elevated at a period not remote from the age of the great volcanic outflow of the Sierra Nevada.

Yours, sincerely,

W. M. GABB.

The minutes of the Board of Officers and Council were read.

Pending nominations, 703 to 707, and new nominations, 708, 709, 710, were read.

And the Society was adjourned.

Stated Meeting, December 6th, 1872.

Present, 13 members.

Vice-President, Mr. FRALEY, in the Chair.

Letters accepting membership were received from Mr. Broca, dated Paris, November 14th, and Mr. Hale, dated Clinton, Ontario County, Canada, November 26th, 1872.

Photographs of Mr. B. S. Lyman and Mr. W. M. Gabb were received for the Album.

A letter desiring the establishment of correspondence, was received from Mr. W. A. Smith, Secretary of the Tennessee Philosophical Society, dated Columbia, Tennessee, November 21st. On motion, the Society named was ordered to be placed on the list of correspondents to receive the Proceedings.

A letter from M. de Koninck, dated Liège, September 3d, requesting the Society to supply deficiencies in his suite of its Proceedings, was read, and, on motion, the request granted.

Letters of acknowledgment were received from the Carolinian University, at Lund, August 1st (XIV., i. ii., 73 to 85); the Physical Society, at Berlin, September 1st (XIV., i. ii., 83 to 86); the Society at Bonn, August 6th (84 to 86); the

Batavian Society, at Rotterdam, August 29th (XIV., iii., 87); the Holland Society, at Harlem (86), requesting a supply of deficient parts; the R. Library, at the Hague, July 24th (XIV., iii., 87); and the Rhode Island Historical Society, Providence, November 19th (88).

On motion, the request of the Holland Society, at Harlem, was referred to the Publication Committee, with power to act.

Letters of envoy were received from the University of Lund, August 1st; the Physical Society of Berlin, September 1st; the Royal Academy, at Amsterdam, September 15th; the Batavian Society, at Harlem; and the Holland Society, at Harlem, December 28th, 1871, and June 1st, 1872.

Donations for the Library were reported from the Imperial and Royal Academies at St. Petersburg, Turin, and Amsterdam; the Societies at Moscow, Bremen, Bonn, Harlem, the Hague, Leeds, Quebec, and Salem; the Geological Institute at Vienna; the Physical Society and German Geological Society at Berlin; Dr. C. F. Naumann at Leipsic; the Astronomical Observatory at Turin; the Revue Politique; London Nature; Lund University; M. L. de Koninck at Liège; the Royal Astronomical Society; Old and New; American Journal of Science; the American Oriental Society; the Cornell Era; the Franklin Institute; the Medical News; and the Philosophical Society of Washington.

The death of Mrs. Mary Somerville, a member of this Society, aged 92, was announced by the Secretary.

A letter was read by the Secretary from Mr. Gabb, dated Museum of Comparative Zoology, Cambridge, Mass., December 3d, giving additional information respecting the date of the emergence of the Isthmus of Panama, in a note to be added to his memoir on the Geology of Santo Domingo.

The Annual Report of the Treasurer was read.

The Annual Report of the Publication Committee was read.

Pending nominations, Nos. 703 to 710, and new nominations, Nos. 711, 712, were read.

The following resolution was offered by Mr. Price and agreed to, and the accompanying letter ordered to be placed upon the minutes:

Resolved, That the Curators be authorized to deliver the Continental Congress Chair to the Mayor, taking an acceptance of it from Councils, that it shall be placed in Independence Hall, subject to be reclaimed at any time by this Society.

To Hon. William S. Stokely, Mayor of the City of Philadelphia :

We herewith deliver into the custody of the City of Philadelphia an Arm Chair used by the Continental Congress, now belonging to the American Philosophical Society, that it may be placed in the Hall of Independence, and accepted by Councils, subject to be at any time reclaimed by said Society.

(Signed) JOSEPH CARSON,
ELIAS DURAND,
HECTOR TYNDALE, } *Curators.*

December, 1872.

The Librarian stated that a large number of books and brochures needed binding; that the book-cases had again become overcrowded by accessions; that certain classes of books were seldom or never referred to; that the catalogue in MS. of the Theological books and pamphlets was nearly finished; and suggested that the book-cases might be relieved and a benefit be conferred on learning by depositing the Chemical, Mineralogical, and Geological books, temporarily, in the new building of the University of Pennsylvania.

On motion of Mr. Ruschenberger, it was

Resolved, That the Committee on the Library be requested to consider the expediency of depositing in the library of the University of Pennsylvania certain books now in the library of the Society, which are not much called for; and in case they shall deem the same expedient, then to report a plan for carrying the same into effect, which will insure the use of the books to the members of the Society, and also provide for the safe keeping of the books so deposited, and their return to the Society when called for.

And the Society was adjourned.

Stated Meeting, December 20th, 1872.

Present, 13 members.

Vice President, Prof. J. CRESSON, in the Chair.

A letter from the Librarian of the Pennsylvania Historical Society, dated Philadelphia, Dec. 13, was read, requesting the completion of their set of Transactions and Proceedings A. P. S., which on motion was granted, and the Librarian authorized to act accordingly.

Letters of similar import from the Cornell University and State Normal School at Fredonia, were on motion referred to the Publication Committee with power to act.

A letter of envoy was received from Mr. Thomas Bland, New York, 42 Pine Street, Dec. 16th, on the part of Gov. Rawson, of Barbadoes, presenting to the Society's Library a copy of his report on the population of the island.

The death of a member, Mr. Thomas Sully, at Philadelphia, on the 6th ult., aged 89 years, was announced by the Secretary.

The death of a member, Dr. Renè La Roche, at Philadelphia, on the 9th inst., aged 77 years, was announced by Mr. Fraley, and on motion, Dr. Carson was appointed to prepare an obituary notice of the deceased.

The death of a member, Dr. Samuel L. Hollingsworth, at Philadelphia, on the 14th inst., aged 57 years, was announced by Mr. Fraley.

Mr. Cope desired to place on record an abstract, which he communicated orally, of a paper on the Zoological Divisions of the Earth, as proposed by Slater, Huxley and others, giving his preference to that of Slater, and citing the numbers of species, etc., already described.

Dr. Wilcox exhibited a Japanese Magic Mirror, the property of E. C. Bittinger, U. S. N., and carrying on its back side the inscription "Elevation—In the dust." He read two letters written by Prof. John Tyndall to Mr. Alex. Johnson, in answer to a request for an explanation of the physical phenomena of these mirrors, used in the Buddhist cultus.

Prof. Marsh gave a short account of the more remarkable results of his explorations in the Rocky Mountains since

1870, viz.: His discovery of the first American fossil pterodactyles, cheiroptera, marsupials, birds with biconcave vertebræ, monkeys (eocene) of low type, and dinoceria, a new order of horned proboscidians with canine teeth.

Prof. Cope dissented from the propriety of at present erecting the proboscidians so discovered into a separate order, merely on the ground of their possessing horns and canines, and gave his reasons.

Prof. Marsh also gave an interesting account of Mr. Clarence King's detection and exposure of the "Arizona Diamond Fraud," and his own observations of the locality, which is actually in Colorado, and not in Arizona. Had the fraud not been exposed by the prompt energy of Mr. King before the setting in of the deep snows, great suffering and loss of life and a vast plunder of property would have ensued.

The Report of the Committee of Finance was read by its Chairman, and the appropriations for the ensuing year recommended therein, were on motion ordered:

Salary of Librarian	$700
Salary of Assistant Librarian	300
Salary of Janitor	100
Binding Books	200
Subscription to Journals	50
Insurance	200
Hall Committee	200
Petty expenses of Librarian	150
Publications in addition to the interest on the Publication Fund	2,500
General Expenses, including the Commissions of the Treasurer	860
	$5,310

Pending nominations, Nos. 703 to 712, and new nominations, 713, 714, were read.

Mr. Fraley reported the receipt of fr. 694.50 from Drexel, Hayes & Co., agents of the Society in Paris, being interest on French Rentes placed to the credit of the Michaux Legacy Fund, of which fund, he explained, $300 had already been paid to the Park Commissioners to defray expenses in establishing the Michaux Grove in the City Park at Fairmount.

The meeting was then adjourned.

COMMUNICATION ON THE DISCOVERY OF NEW ROCKY MOUNTAIN FOSSILS,

MADE BY PROF. O. C. MARSH

At the meeting of the American Philosophical Society, Dec. 20, 1872.

Professor O. C. Marsh, of Yale College, gave a brief account of some of the more important results of his paleontological researches in the Rocky Mountain region during the last three years. He had directed his attention mainly to the extinct vertebrates of the Cretaceous and Tertiary formations, and had obtained more than 200 species new to science, about 150 of which he had already described. Among the new types of fossil vertebrates thus discovered, were Pterodactyls, or Ornithosaurians, the first detected in this country. He had described three species of these from the Cretaceous of Kansas, all of gigantic size. Prof. Cope had subsequently redescribed two of the species in the Proceedings of this Society (Vol. XII. p. 420), but the names *Pterodactylus occidentalis*, Marsh, and *P. ingens*, Marsh, given in the American Journal of Science (Vol. III. p. 241) had priority. A second and quite unexpected discovery of great interest was that of the *Ichthyornidæ*, or cretaceous birds with biconcave vertebræ, two species of which Prof. Marsh had recently described. A third discovery was that of fossil *Cheiroptera*, or Bats, not before observed in this country. The three known species were found in the Eocene of Wyoming. A fourth new type was that of extinct Marsupials, also from the Eocene. A fifth discovery of great importance, was that of fossil *Quadrumana*, several genera and species of which he had found in the Eocene. Prof. Marsh stated that he had obtained indications of fossil Monkeys in this formation more than a year before, but had delayed announcing the discovery until the evidence was conclusive. A sixth new type of animals, and perhaps the most interesting of all, were the gigantic Eocene Mammals, which he had recently assigned to the new order *Dinocerea*. These animals had limb bones somewhat like those of Proboscidians, as stated in the original description of the type species, *Tinoceras anceps*, Marsh. The skull, however, presents a most remarkable combination of characters. It is long and narrow, and supported two, and possibly three, pairs of horns. The top of the skull was concave, and on its lateral and posterior margin there was an enormous crest. There were large decurved canine tusks resembling those of the Walrus, but no upper incisors. The six premolar and molar teeth were quite small. Several species of these remarkable animals have already been described, but at present they cannot all be distinguished with certainty. In addition to the type species already mentioned, Prof. Cope has given the name *Loxolophodon semicinctus*, to a single tooth, which may possibly belong to this group. Dr. Leidy has described a characteristic specimen as *Uintatherium robustum*, and a canine tooth, apparently part of the same animal, under another name. The remarkable feature of the skull in this group was first indicated in the name *Tinoceras*, which the speaker had proposed for one of the genera. Prof. Cope subsequently proposed the name *Eobasileus*, but was mistaken in regard to the main char-

acters of the skull. What he called incisors are canines; and the large horns are not on the frontals, but on maxiliaries. The top of the skull moreover is not convex, but concave, and the occiput is oblique, and not vertical. Prof. Marsh stated that he had described several species of this group, one of the most singular of which, *Dinoceras mirabilis*, Marsh, was represented in the Museum of Yale College by a nearly perfect skeleton, and portions of several others. In all of the species the limb bones differ considerably from those of Proboscidians, while the skull is so totally unlike anything hitherto known, that he could not refer these extinct animals to that group, and hence had proposed for their reception the order *Dinocerea*.

ON A SPECTROSCOPIC OBSERVATION OF THE AURORA OF APRIL 10, 1872.

BY PERSIFOR FRAZER, JR.

(*Read before the American Philosophical Society, April* 19, 1872.)

On the night of April 10, 1872, a very beautiful Aurora was seen from Philadelphia, spreading over 25° or 30° of the Northern Heavens.

The night was clear, and the wind was from N. W. and slightly cool. A heavy bank of cloud covered about one-sixth of the horizon to the north, and from the crest of this bank the Aurora seemed to proceed, shooting up fitfully in sprays and bundles to near the zenith, and traversing from west to east and back again with average rapidity. One detached streamer crossed the zenith from N. E. to S. W., and remained permanent in position, giving only occasional fluctuations of light.

Observations were commenced with a Browning angle measuring spectroscope, the light condensed through a 13 foot focus, 9 in. diam. lens.

The observations were made solely with reference to the green line in the Aurora, and the purpose in view was to verify or not the observations of Piazzi Smith in regard to its coincidence with the green hydro-carbon line seen at the base of every candle and illuminating gas-flame.

Four observations gave the following results :

1.	Green line of Aurora......................	92°	35′	0″
2.	" "	92°	35′	0″
3.	" "	92°	48′	0″
4.	" "	92°	20′	0″

The line became exceedingly faint during the 3d and 4th observations

so as to present great difficulties in placing the cross wires on it, but as the mean of these deviations, great as it is, is very nearly the two first recorded, I have proposed to let the late observations stand, and rate their value as 1 each, that of each of the first two being called 5.

This would give the value of this line as.............	92°	34′	49.8″
A series of careful observations in the D lines and the F line, gave as a mean of the former..........	91°	52′	30″
And for the latter..................................	95°	13′	0″
The angular distance between D and F...........	3°	20′	30″

A curve was projected on the plan now generally adopted by observations on some ten lines, and by reference to this parabola, the mean length of the green line was found to be 563.

It would correspond to 66 of Roscoe or 176.88 Kirchoff. Lines in Rb, and Cs, and Ba, lie very near it, but none exactly coincides with it, nor *is there any absorption line in the Solar Spectrum which does.*

NOTICE OF PROBOSCIANS FROM THE EOCENE OF SOUTHERN WYOMING.

BY EDW. D. COPE.

(*Telegram dated Black Buttes, Wyoming, August* 17, 1872, *read by the Secretary at the meeting of the American Philosophical Society, September* 20*th*, 1872.)

I have discovered in Southern Wyoming the following species: LOXOLOPHODON, Cope. Incisor one, one canine tusk; premolars four, with one crescent and inner tubercle; mola's two; size gigantic. L. *cornutus;* horns tripedral, cylindric; nasals with short convex lobes. L. *furcatus*, nasals with long spatulate lobes. L. *pressicornis*, horns compressed subacuminate.

(Signed) EDWARD D. COPE,
U. S. Geological Survey.

[*Note by the Secretary.*—The above telegram was so badly transmitted by the operators as to be read with difficulty, and the precise forms of the specific names could not be certified until the return of Prof. Cope from the field.]

Obituary Notice of Edward Miller, Civil Engineer.

Prepared at the request of the American Philosophical Society, and read at a meeting of the Society, April 5, 1872.

By Solomon W. Roberts, Civil Engineer.

Edward Miller was born in Philadelphia on the 6th of January, 1811. He was the third son of William Miller, who was the Secretary of the Philadelphia Marine Insurance Company, and had been Commissioner of the Revenue of the United States at the City of Washington. He was a gentleman of the old school, remarkable for his punctilious politeness, and for a high sense of honor; and was held in high esteem by many prominent citizens of Philadelphia, and in particular by Mr. Nicholas Biddle, with whom he was very intimate. Mr. William Miller and his family were connected with the first Presbyterian Church of Philadelphia for many years.

Edward Miller was educated at the University of Pennsylvania, where he graduated, with Mathematical Honor, when seventeen years of age. Immediately afterwards he entered the Engineer Corps on the Lehigh Canal, of which Canvass White was the Chief Engineer. Mr. White had been one of the Principal Engineers of the Erie Canal of New York, and he was a gentleman of fine character and much experience. He had made pedestrian tours along the lines of the principal canals of Great Britain, and he was a man of sterling integrity and of great industry. When Edward Miller joined the corps, the Resident Engineer was Sylvester Welch, a man of remarkable energy of character, who planned the Portage Railroad and directed its construction across the Allegheny Mountain, and who was afterwards the Chief Engineer of the State of Kentucky. With him was his brother, Ashbel Welch, since the Chief Engineer of various important works in New Jersey, and for several years, until the leasing of the lines, the President of the United Companies of that State. On the Lehigh at the same time were W. Milnor Roberts, now the Chief Engineer of the Northern Pacific Railroad; Solomon W. Roberts, now Chief Engineer and Superintendent of the North Pennsylvania Railroad; A. B. Warford, Geo. E. Hoffman, Benjamin Aycrigg, and several other well known engineers. It was a good school.

Canvass White had been an officer of volunteers in the war of 1812, and had been badly wounded at Fort Erie. He was a strict disciplinarian, and set a fine example of conscientious discharge of duty, even when suffering from ill health and much bodily weakness. Henry Clay, when recommending him for Engineer of the Chesapeake and Ohio Canal, said: "No man is more competent, no man more capable; and while your faith in his ability and fidelity increases, your friendship will grow into affection." He died in 1834 of pulmonary disease, when 44 years of age, and is buried at Princeton, New Jersey, where he had resided as Chief Engineer of the Delaware and Raritan Canal.

The principal manager of the business of the Lehigh Canal and Navigation Company at that time, was Josiah White, a member of the Society of Friends; a man whose abilities and great public services in developing the resources of Pennsylvania, were worthy of a more fitting memorial than they have yet received.

From the time when Edward Miller joined the corps at Bethlehem, on the Lehigh, in 1828, until the canal was completed in the following year, he was much liked by his comrades, and an intimacy grew up between him and the writer of this notice, which lasted without interruption until his death, a period of more than forty years. In the autumn of 1829, they entered together the service of the State of Pennsylvania, on the western division of the State Canal, of which Sylvester Welch had been appointed the Principal Engineer.

That work was finished in December, 1830, and early in 1831 Edward Miller went abroad and passed some months in England, where he carefully examined the Liverpool and Manchester, the Cromford and High Peak, and other railways in Great Britain. He was provided with excellent introductory letters, and he acquired a large amount of valuable professional knowledge. Soon after his return home, Sylvester Welch, who had become the Principal Engineer of the Portage Railroad over the Allegheny Mountain, appointed Edward Miller to be his Principal Assistant in charge of the Machinery of the Inclined Planes. Mr. Miller designed the stationary engines and other machinery for ten inclined planes, and superintended their construction in Pittsburg. The plans were novel and ingenious, and the rapid manner in which the planes on the mountain were worked, as compared with those elsewhere, showed their great superiority. In the spring of 1834 the railroad over the mountain was opened for public use, the rise from the canal-basin at Hollidaysburg to the summit being 1,400 feet in a little over ten miles. The work attracted much notice, and many persons of distinction visited it. It served its purpose until it was superseded by the improved line of the Pennsylvania Railroad.

Throughout his career, Edward Miller illustrated the advantages of literary and scientific training to a man of business. He surrounded himself with good books and made good use of them. He turned his attention to Geology, and studied it with reference to its influence upon topography, and upon the contour lines of the country in which he was engaged in railroad explorations and locations, and especially with reference to the region of the Allegheny Mountains in Pennsylvania, of which he traced a crest line for more than forty miles. Soon after he grew up to manhood he wrote an essay on this subject for publication.

The first work of which he had the independent charge as Chief Engineer, was the Catawissa Railroad. At that time locomotive engines had been but a few years in use for miscellaneous traffic; they were much lighter and less powerful than those now used, and high speeds and long trains were very little known. The ponderous engines, weighing thirty

or forty tons, with steel tires and steel fire-boxes, burning anthracite coal, and rushing along over varying grades with a speed and a power which continue to impress the imagination even of those whose daily duty it is to direct their course, had then no existence.

The Catawissa Railroad has a summit-tunnel about 1,200 feet long, excavated through rock. The rise from the Susquehanna at Catawissa to the tunnel on the head-waters of the Little Schuylkill, is very nearly 1,000 feet in about thirty miles. Mr. Miller fitted his line to the ground with very great care, and in such a way that the road has no grade exceeding thirty-three feet in a mile, so as to economize locomotive power to the greatest possible extent. This necessitated the building of several very high bridges to carry the grade across lateral ravines entering the main valley. This road continues to be in successful use. The location was a very bold one, nothing like it having been attempted in the country before, and it showed a very considerable degree of originalty and self-reliance on the part of the young engineer who made it.

In June, 1836, while living at Catawissa, Mr. Miller was happily married to Miss Jessie Patterson Imbrie, of Philadelphia. His wife survives him with a large family of children, and their eldest son, Mr. James Imbrie Miller, now holds a high position in British India, as Chief Engineer of the Government Railways in Rajpootana, a large district of Central India, with the rank of Lieutenant-Colonel of Engineers.

Soon after his marriage, Edward Miller was, for some time, the Chief Engineer of the Morris Canal of New Jersey.

Before the completion of the Catawissa Railroad, he left it to become Chief Engineer of the Sunbury and Erie Railroad Company, of which Nicholas Biddle was then the President. He proceeded to explore the country between Sunbury and Erie, much of which was a wilderness. It was said at the time, that in the wildest part of it there was but one house near the line for sixty miles. A considerable time was occupied in preliminary surveys, but the construction of the work did not go on until long after, on account of the failure of the United States Bank and the temporary collapse of credit that ensued.

The people residing in the southern tier of counties in the State of New York, were resolutely bent on having a railroad from the Hudson River to Lake Erie, to rival the Erie Canal. A charter was obtained and the work undertaken. Thus arose the New York and Erie Railroad Company, which has had such an extraordinary history since, a history which, to one familiar with it, seems like a romance.

By its charter the company was prohibited from locating any part of its road outside of the territorial limits of the State of New York. The long line was cut up into several parts, with independent Engineers upon each, and confusion followed as a matter of course. Edward Miller was employed as a Consulting Engineer to write a report upon what was going on. This he did so much to the satisfaction of the Board of Directors, that he was soon after appointed Chief Engineer of the whole line from

the Hudson to Lake Erie. When it is considered that he was a citizen of Pennsylvania, and only thirty years of age, it is remarkable that he should have received such an appointment.

The location of the railroad was materially changed, additional legislation was obtained, a part of the line was laid within the limits of Pennsylvania, on the Upper Delaware; and Mr. Miller continued to be the Chief Engineer for about three years, and until the work was suspended for the want of funds. The first division of the road was opened for public use while he had charge of it.

It may be remarked, in this connection, that a great change has come over the general tenor of legislation in the several States of the Union, on the subject of internal improvements.

Men change and die, but the mountain ranges remain and the streams flow on in their old channels. The arbitrary lines drawn upon the map as political divisions, cease, more and more, to act as barriers to obstruct the construction and use of railroads, which the people feel that they need to facilitate their free intercommunication, and thus the railroads of the country become one of the most powerful means of securing a more perfect Union.

After leaving the New York and Erie Road, Mr. Miller returned to Philadelphia, and became President of the Harrisburg and Lancaster Company, which post he held for two years, and while holding it he visited England as financial agent of the Company. In 1845 he was the Chief Engineer of the enlargement of the Schuylkill Navigation, a work by which the tonnage of the boats upon the Schuylkill River and Canal has been considerably more than doubled.

On the 18th April, 1845, Edward Miller was elected a member of the American Philosophical Society.

In 1856, the Pennsylvania Railroad Company was chartered. The prompt construction of a continuous railroad from Philadelphia to Pittsburg was demanded by public opinion; and, in the face of much opposition, the City of Philadelphia, in its corporate capacity, subscribed five millions of dollars to the stock of the company.

Mr. John Edgar Thomson, now the distinguished President of that powerful and prosperous corporation, was appointed its Chief Engineer. Mr. Thomson is a native of Pennsylvania, born in Delaware county, and his great success as a railroad engineer in Georgia, recommended him for his new post of professional honor and responsibility. How worthily he was to fill it is best shown by the annual reports of the Pennsylvania Railroad Company for the last twenty-five years. Edward Miller became the Associate Engineer of the Western Division, the most difficult part of the line, and under his supervision the surveys and location of the road from Altoona to Pittsburg were made, under Mr. Thomson as Chief Engineer. After Mr. Thomson became President of the Company, Mr. Miller succeeded him as Chief Engineer.

How efficiently these gentlemen aided each other, and thus promoted

the great interests confided to their care; with what freedom from professional jealousies they acted, and what magmanimity characterized their intercourse, is well known to the writer of this imperfect tribute to the memory of one whose loss we now deplore, and who considers it to be a worthy example to young men entering upon the arduous life of a Civil Engineer.

Mr. Miller remained in the service of the Pennsylvania Railroad Company for about six years, and in 1852 he visited England on business of that corporation.

In February, 1853, he became the Chief Engineer of the North Pennsylvania Railroad, and continued upon that line until June, 1856, in that year being President of the Company. He located the railroad from Philadelphia to Bethlehem, and part of it was completed while under his charge. A continuous line was also located from Bethlehem to the State line of New York at Waverley, and various other surveys were made to the Delaware Water Gap and elsewhere.

In 1856, Edward Miller removed to Missouri, having been appointed Chief Engineer of the Pacific Railroad of that State. He held that post for a few years; and, having gone to reside on a large farm near the Missouri River, about six miles from the Kansas line, the war broke out, and he found himself with a large family in a position of great peril. The progress of the railroad had stopped, and a terrible, irregular warfare filled all Western Missouri with fear. After enduring the evils of this position for a time, Mr. Miller returned to Philadelphia, leaving that home in the West which he had done much to improve, and which had for a while lost its value.

Although many millions of dollars had been disbursed under his direction on various public works, his accumulations, after many years of labor, had not been large. He was proud of his profession, looking upon it as the art of directing the great sources of power in nature to the use and benefit of man, and he considered the Civil Engineer to be not only the interpreter between the man of science and the mechanic, but also a captain of industry, bound in honor to set a good example to those working under him of all uprightness and integrity.

He had reached the age of fifty years, and he felt the importance of making a more adequate provision for his family. Through the kind assistance of Mr. John Edgar Thompson, he became a partner in a large contract for the completion of the Philadelphia and Erie Railroad, which proved to be profitable, and he was afterwards interested as a contractor on the Warren and Franklin and Kansas and Pacific Railroad. The favorable results of these undertakings enabled him to leave his family in easy circumstances.

In January, 1871, he was sixty years old, and about that time he found himself suffering from serious disease, the symptoms of which had begun to develop themselves some time before. An internal tumor, of a cancerous nature, was found to exist and to be increasing, and the resources of

medical science and skill failed to remove it. He lived for about a year, after the nature of his disease became known to him, and at times he suffered great pain. In the latter part of the time he could take but little food, and his strong frame, more than six feet in hei ht, became very much emaciated. He was nursed with the tenderest care; and a supply of the bark of the Cundurango plant from South America was obtained for him, which has been highly spoken of as a remedy for cancerous diseases, but which failed in this case.

The Christian character of Edward Miller was beautifully exhibited in his last illness, and he was a fine example of "the power of religion upon the mind in retirement, affliction, and at the approach of death." He had long been a member and an elder of the Presbyterian Church. Although a person of very positive opinions, and free in the expression of them, he was a broad-minded man, and some of his nearest friends were not of his religious communion. At the last, he passed away serenely to his final rest, full of Christian faith and hope.

He died on the first of February, 1872, in the sixty-second year of his age, at his house in West Philadelphia, and was buried at Woodlands Cemetery.

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